

**UNDERWRITERS LABORATORIES INC.
REPORT OF
HEPTANE SPILL FIRES
CONDUCTED FOR
INDUSTRIAL RISK INSURERS**

- The Fire Tests Described Herein Were Conducted in The Most Sophisticated, Environmentally Friendly Large Scale Fire Test Facility in the World.
 - NC1838 97NK34585 December 29, 1997

1.0 INTRODUCTION

General

This Test Report describes the Special Service Investigation conducted for Industrial Risk Insurers to develop fire test data relative to the level of protection required for fire scenarios involving Intermediate Bulk Containers (IBCs).

Purpose

The sole purpose of this investigation was to develop test data relative to the protection of storage arrays simulating IBC's using a wet pipe ceiling sprinkler system. The data developed for Industrial Risk insurers, may be provided to the National Fire Protection Association Fire Test Committee.

2.0 TECHNICAL PLAN

The investigation consisted of three fire tests which exposed a 2x2x2 array of steel forms representing stacked IBC's to a running heptane fuel fire positioned within the array. The fuel flow rate was set at 4 gpm for Fire Test No. 1, 6 gpm for Fire Test No. 2, and 15 gpm for Fire Test No. 3. Sprinklers were provided to deliver densities of 0.60 gpm/ft².

3.0 TEST FACILITY

The fire tests were conducted in a 120 by 120 by 54 ft. high room fitted with a 100 ft. by 100 ft. adjustable height ceiling adjusted to a height of 30 ft.

The test rooms are equipped with an exhaust system through a regenerative, thermal oxidizing, smoke abatement system. Make-up air is provided through four inlet ducts positioned along the walls of the test facilities.

The floors of the test facilities are smooth and flat and surrounded with a grated drainage trench to insure adequate floor water drainage from the test area. The water runoff from the suppression system drain is collected through a 180,000 gallon water treatment system.

4.0 EQUIPMENT AND INSTRUMENTATION

Ceiling Sprinkler Systems

For the fire tests conducted in the 120 x 120 ft. test cell, a closed head, wet pipe, automatic sprinkler system was positioned below a movable, smooth, flat, non-combustible ceiling. The fire tests utilized thirty six, 286°F temperature rated, standard response, 5/8 in. nominal orifice, upright style sprinklers installed on 10 by 10 ft. spacings. The sprinklers were supplied through a looped piping system consisting of 2-1/2 in. diameter branchlines. The piping system was supplied with water under adequate pressure and flow to maintain the desired water discharge density for the particular test.

Sprinkler and installation details are described in the Fire Tests section of this Report.

Instrumentation

The instrumentation used in the testing consisted of the following devices:

- Thirty six thermocouples located below the ceiling adjacent to each sprinkler to record ceiling temperatures for fire tests conducted in the 120 by 120 ft. test cell.
- One thermocouple located 6 inches below the ceiling above the ignition location.
- Four thermocouples embedded in a steel beam attached to the bottom of the ceiling directly above the fire.
- Pressure sensors and flowmeters used to measure and monitor the water supply to the sprinkler system.
- Stopwatch and timing devices located within the data acquisition system used to monitor and record significant events during the fire tests.
- Cameras used to capture and record images of the fire tests.

5.0 TEST COMMODITY

The test commodity consisted of eight steel intermediate bulk container shells arranged in a 2 x 2 x 2 storage configuration using 6 inch flue spacing. Each shell measured 48 by 40 by 46 in.

6.0 FIRE TESTS

Test Configurations

A 2 x 2 x 2, array of steel IBC shells, centered under four sprinklers, were used for these tests. The fuel flow rate was set at 4 gpm for Fire Test No. 1, 6 gpm for Fire Test No. 2, and 15 gpm for Fire Test No. 3.

Ceiling Protection

Thirty six 286° F temperature rated, standard response, 5/8 in. nominal orifice, upright sprinklers were installed on a nominal 10 ft. by 10 ft. spacings and mounted a nominal 9 inches under a smooth, flat, non-combustible ceiling assembly. The ceiling sprinkler system was arranged to deliver water through sprinklers discharging densities of 0.60 gpm/ft²

Test Procedure

A one inch pipe used to supply the fuel for the three dimensional heptane fire was positioned within the storage array. The piping was arranged to provide the spill location approximately 6 inches above the base of the uppermost unit through an upturned pipe elbow located at the center intersection of the longitudinal and transverse flue space.

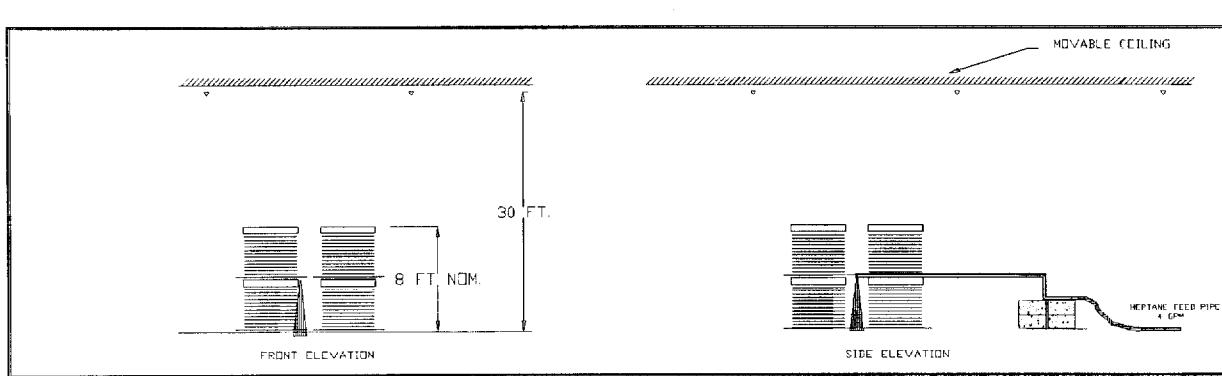
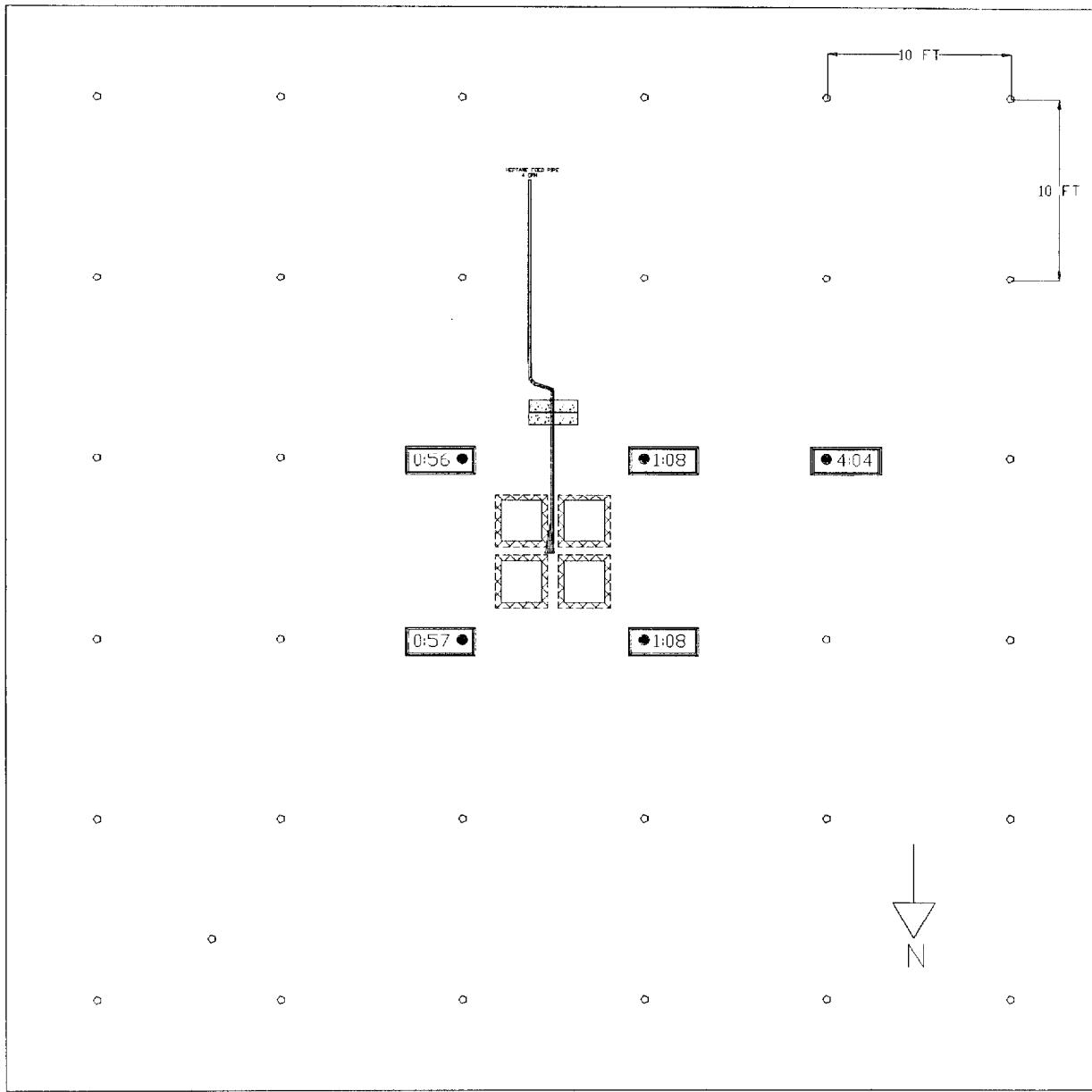
Ignition was accomplished using eight plastic bags each filled with 1 gallon of heptane positioned in the longitudinal and transverse flue spaces. Two additional gallons of heptane were spilled over the plastic bags prior to ignition. The 10 gallons of heptane was ignited with a torch. At the operation of the first sprinkler, the flowing fuel supply was initiated to provide the required amount of heptane flow to the test array.

During the test, time, temperature, and flow information were gathered using high speed data acquisition equipment. Video images were captured and recorded on VHS format video tape.

Results

The salient results are presented in Table 1. Sprinkler operating times are shown in Ills. 1, 2, and 3 for each test. The temperature data for the tests are presented in the Appendix A,B, and C.

FIRE TEST No.1



LEGEND

- 5/8 IN. NOMINAL ORIFICE UPRIGHT STYLE 286°F STANDARD RESPONSE SPRINKLER
- OPERATED SPRINKLER

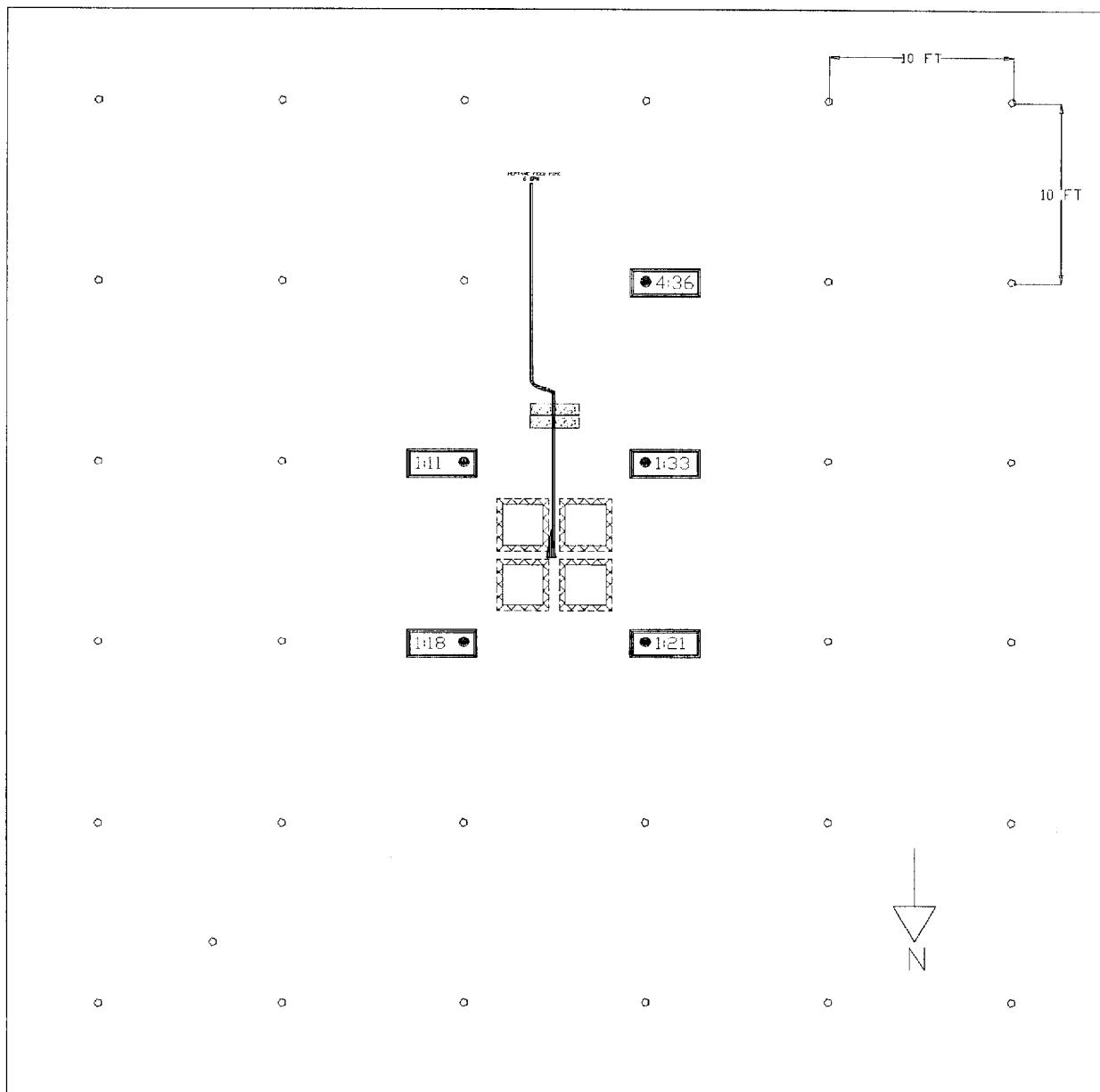


STEEL SHELLS SIMULATING INTERMEDIATE BULK CONTAINER

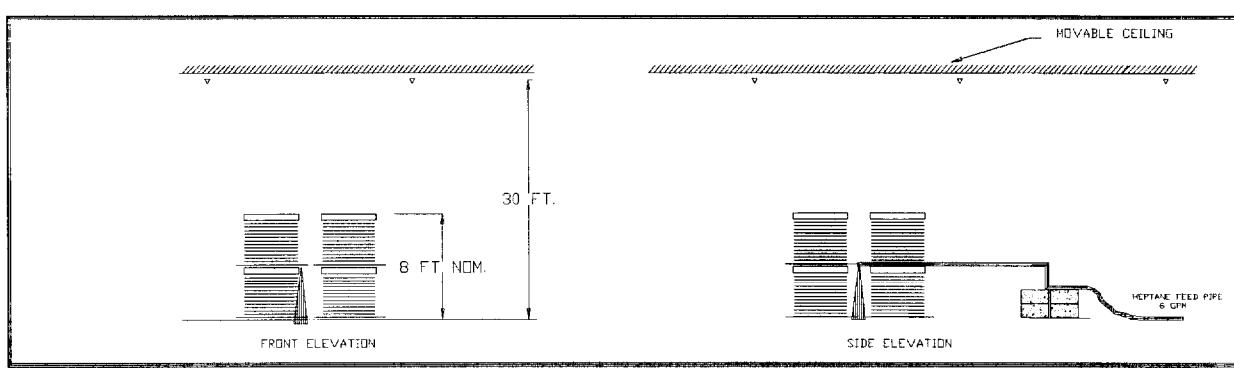
IRI 97NK34585, NC1838

ILL. 1

FIRE TEST No.2



PLAN VIEW



ELEVATION VIEW

LEGEND

- 5/8 IN. NOMINAL ORIFICE UPRIGHT STYLE 286°F STANDARD RESPONSE SPRINKLER
- OPERATED SPRINKLER

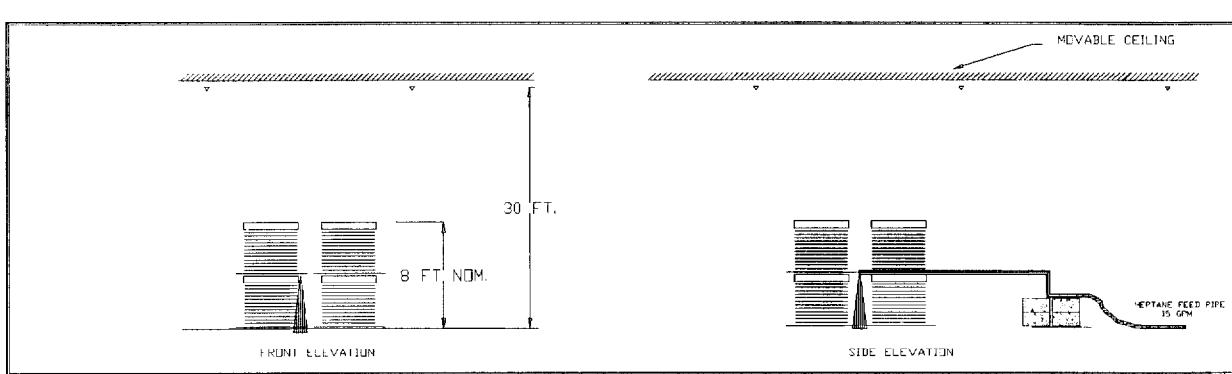
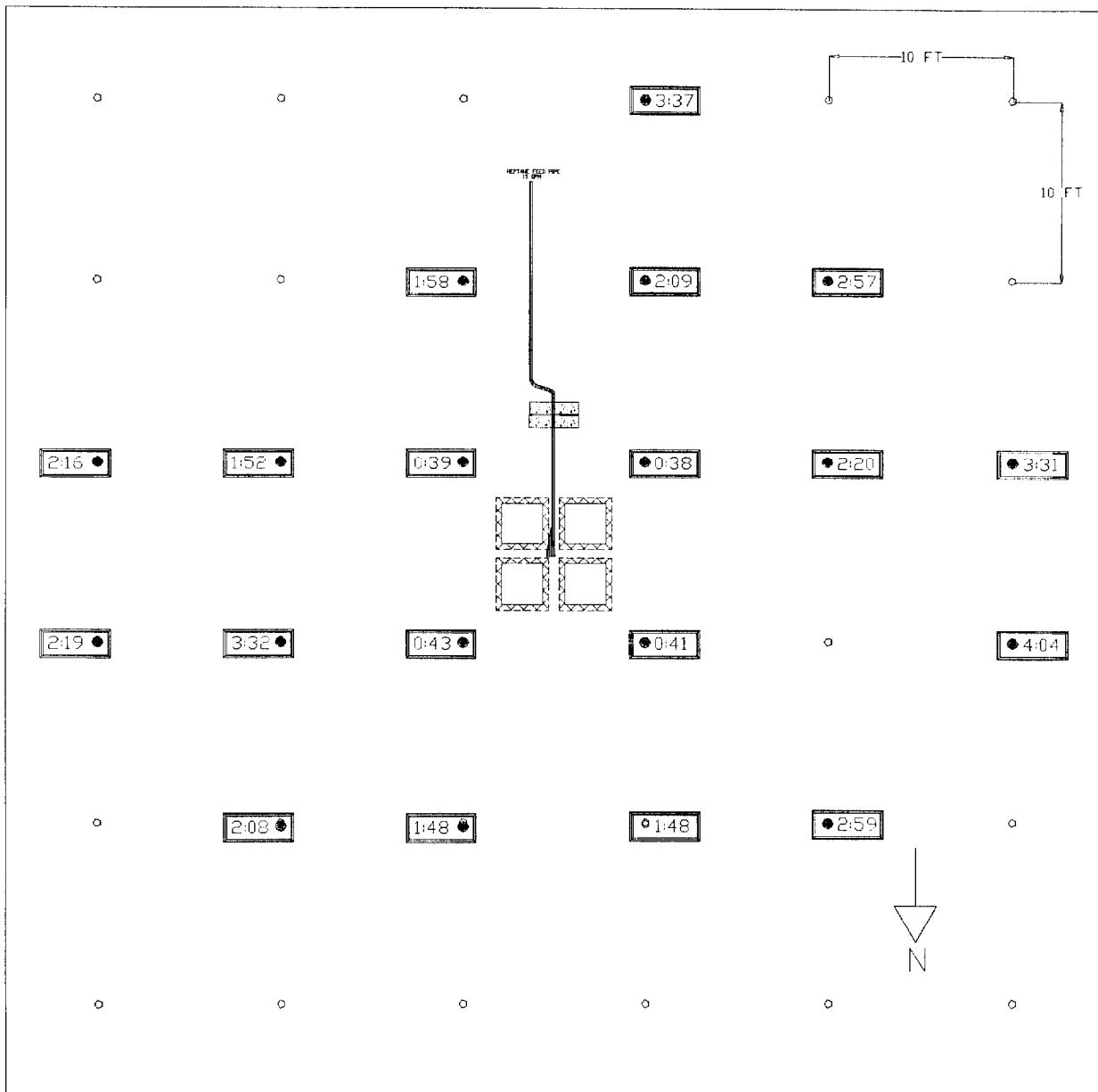


STEEL SHELLS SIMULATING INTERMEDIATE BULK CONTAINER

IRI 97NK34585, NC1838

ILL. 2

FIRE TEST No.3



LEGEND

○ 5/8 IN NOMINAL ORIFICE UPRIGHT STYLE 286°F STANDARD RESPONSE SPRINKLER

● OPERATED SPRINKLER



STEEL SHELLS SIMULATING INTERMEDIATE BULK CONTAINER

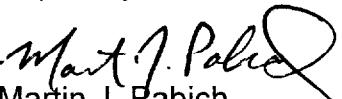
IRI 97NK34585, NC1838

ILL. 3

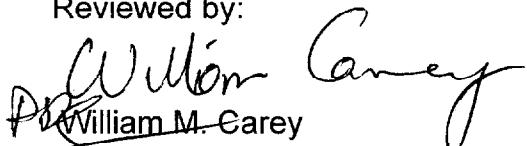
Table 1
Test Parameters and Results

Test No.	Fuel Flow Rate (gpm)	Number Of Operating Sprinklers	Time Of First Sprinkler (sec.)	Time Of Last Sprinkler (sec.)	Test Duration (min.:sec.)	Peak Air Temperature Over Ignition °F (°C)	Peak Steel Temperature Over Ignition °F (°C)
1	4	5	56	244	5:00	275 (135)	207 (97)
2	6	5	71	276	5:00	325 (163)	270 (132)
3	15	19	38	244	4:00	504 (262)	363 (184)

Report by:

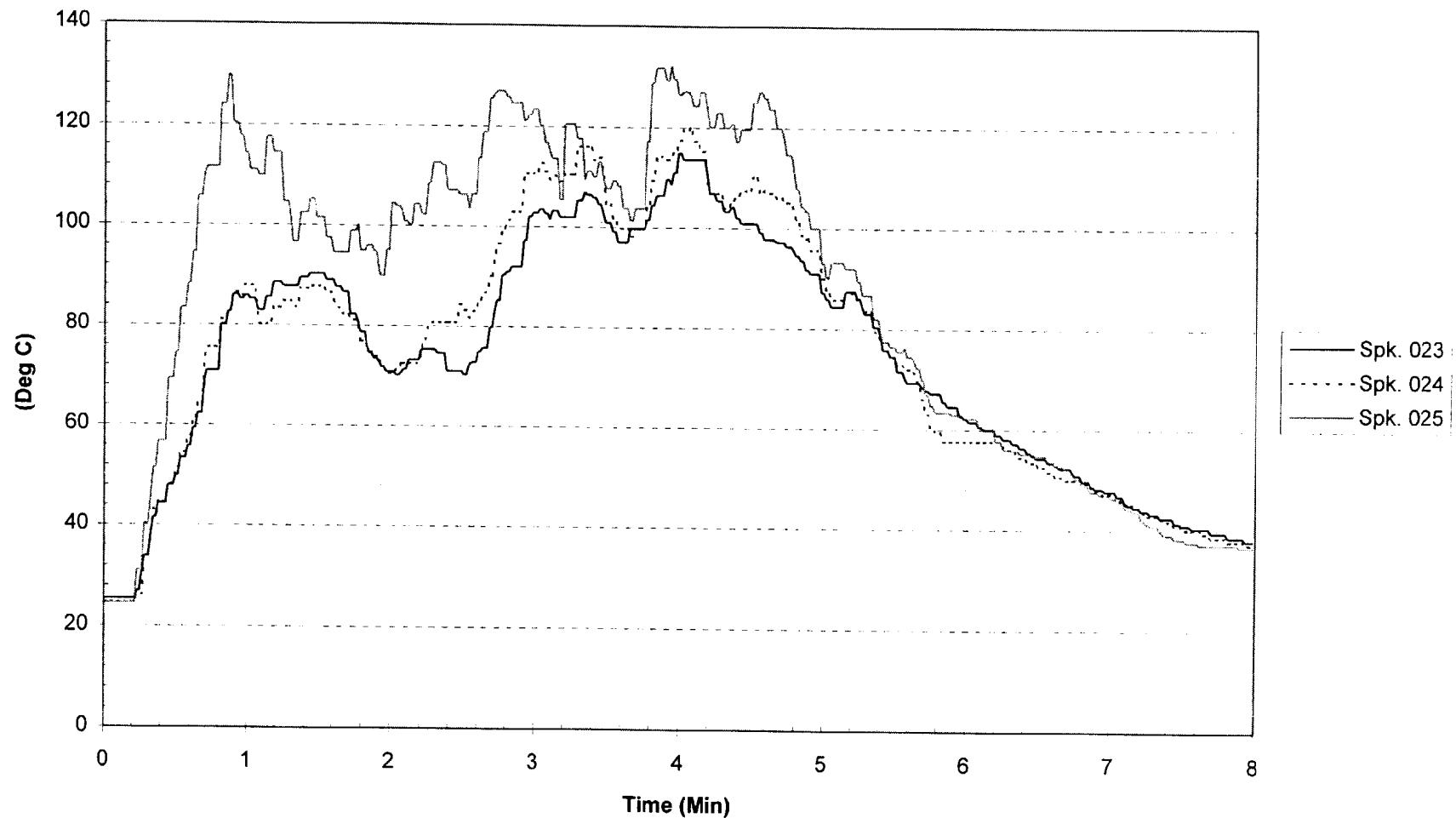

 Martin J. Pabich
 Senior Project Engineer
 Large Scale Fire Research

Reviewed by:


 William M. Carey
 Senior Staff Engineer
 Large Scale Fire Research

APPENDIX A
Fire Test No. 1

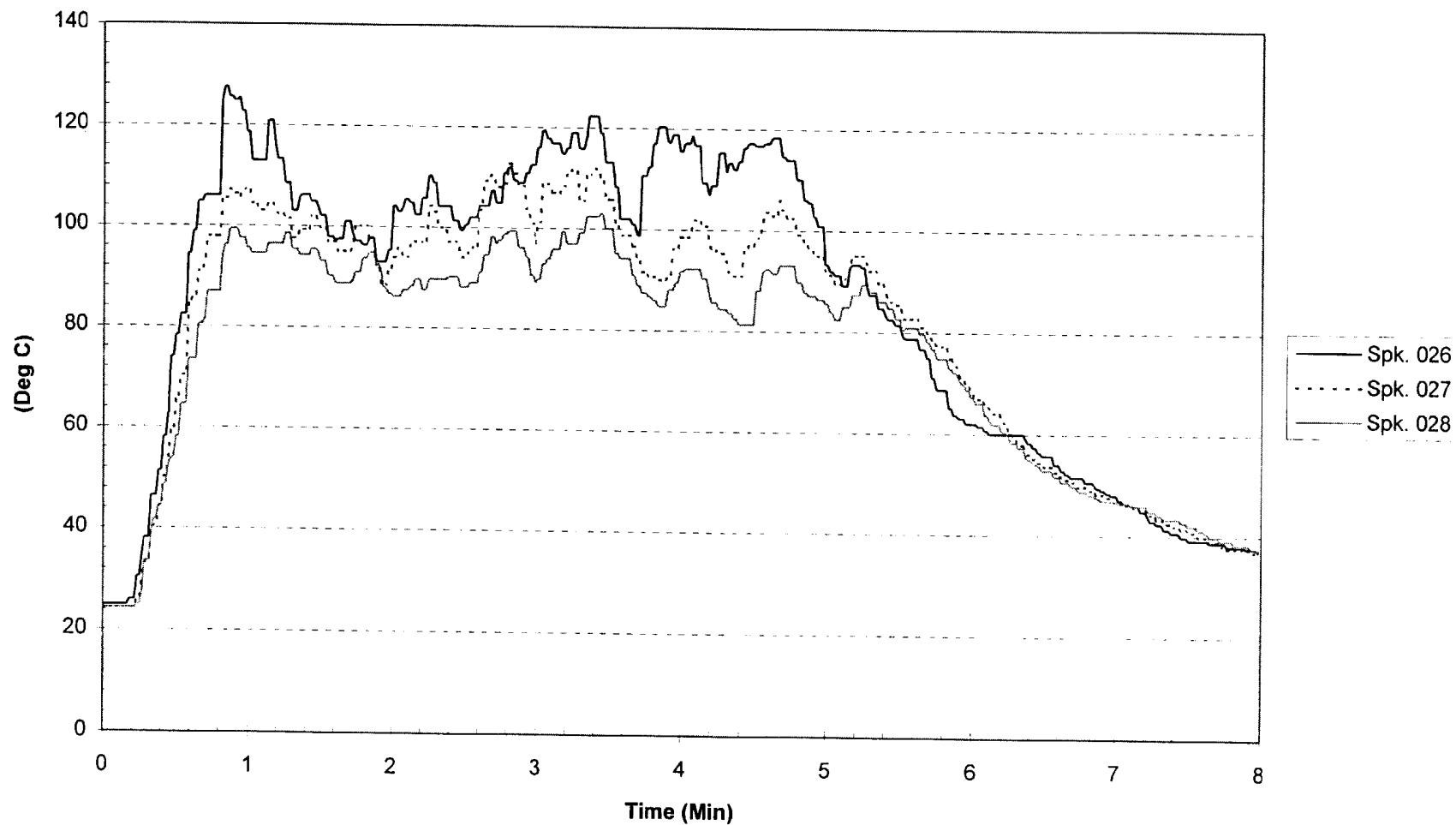
IRI
SP23 - SP25
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

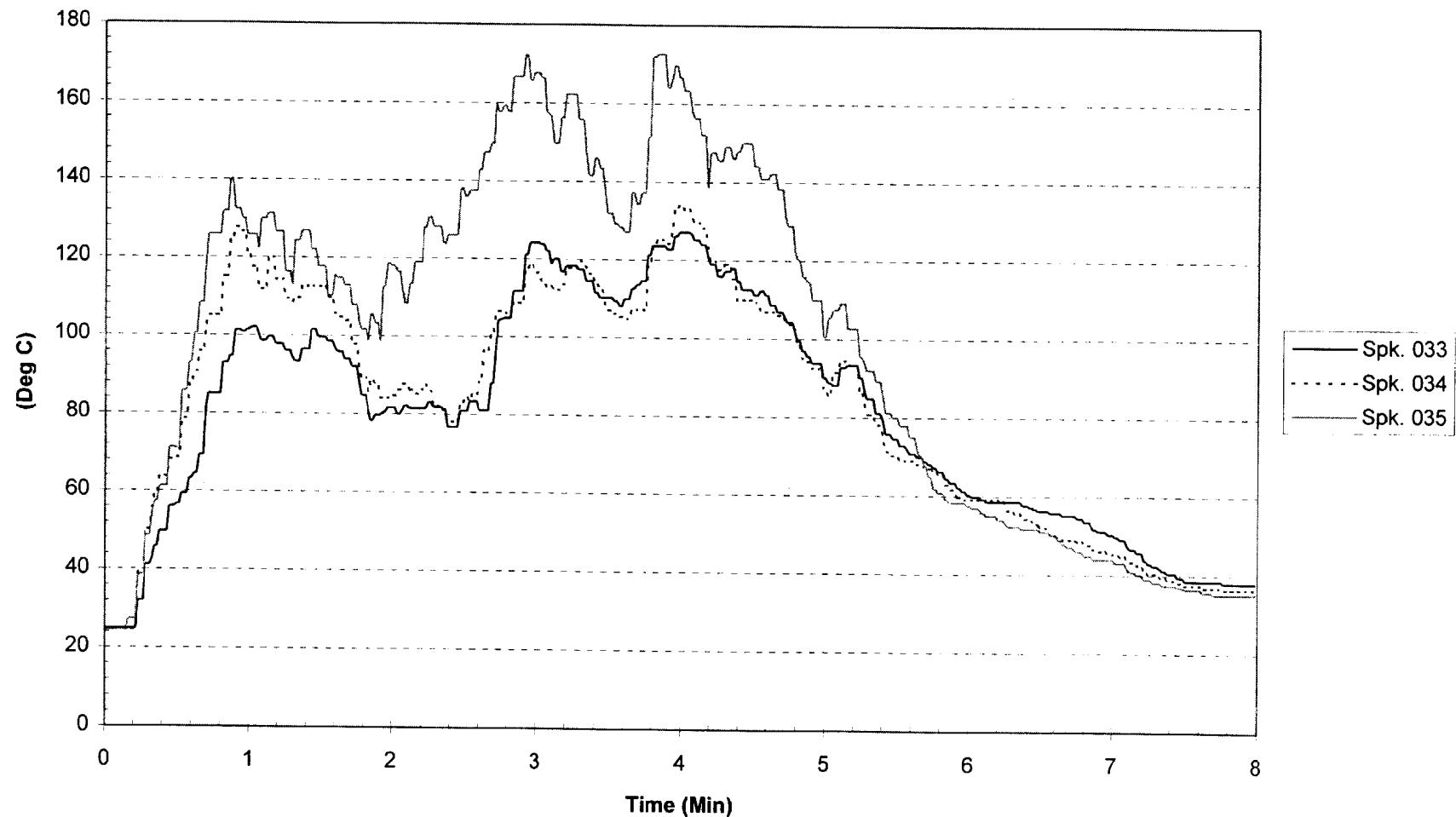
IRI
SP26 - SP28
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

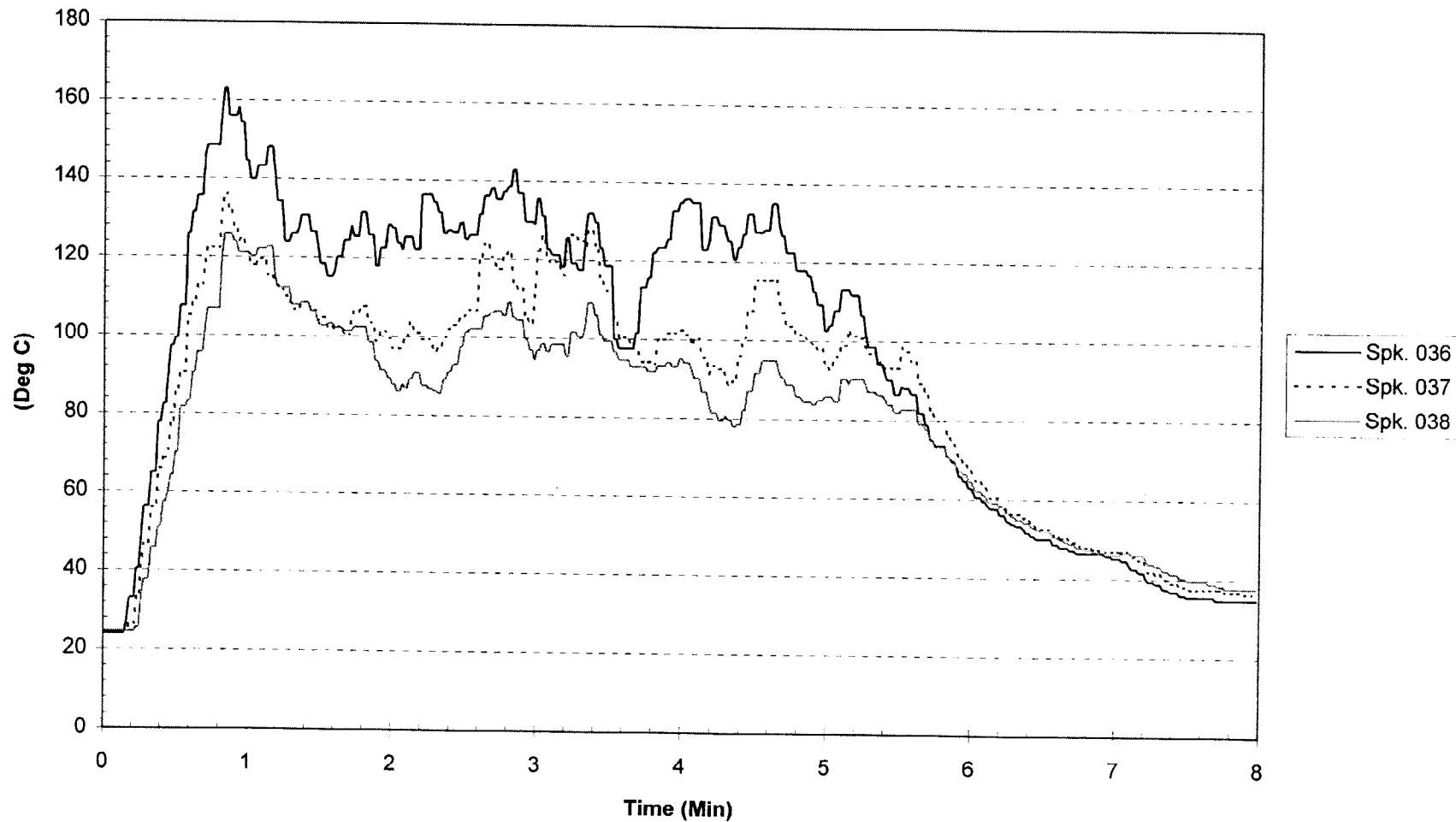
IRI
SP33 - SP35
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

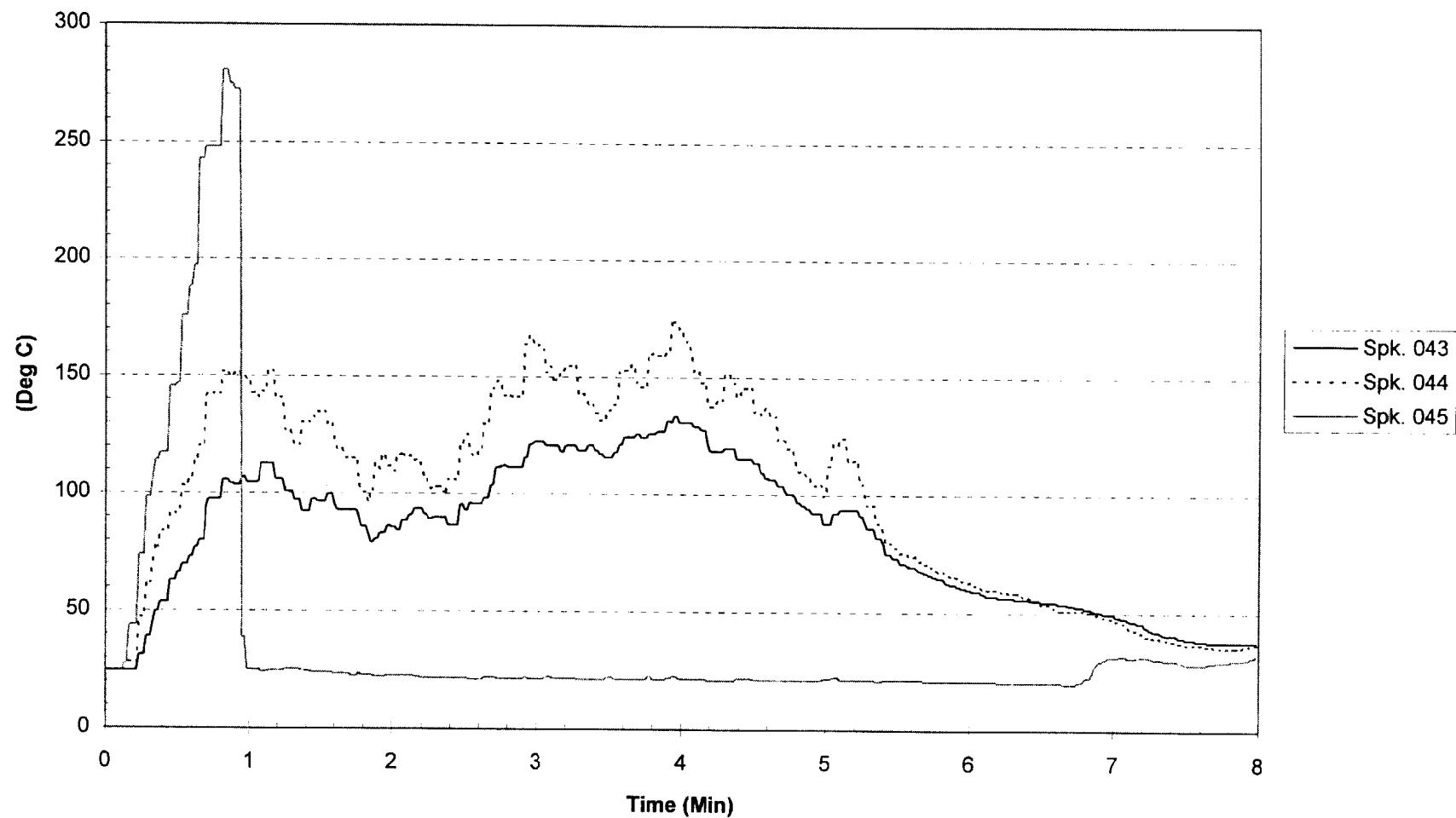
IRI
SP36 - SP38
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

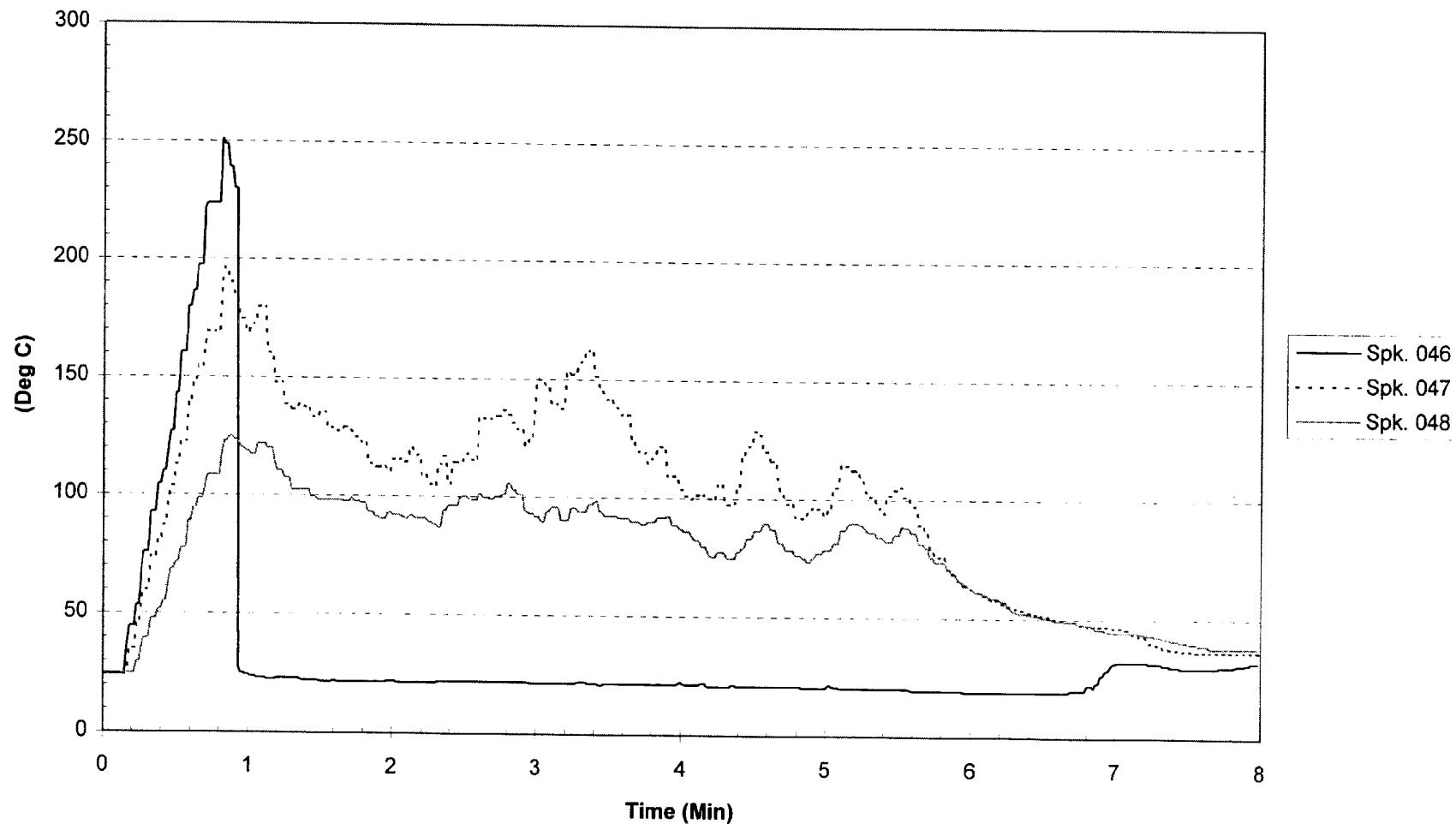
IRI
SP43 - SP45
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

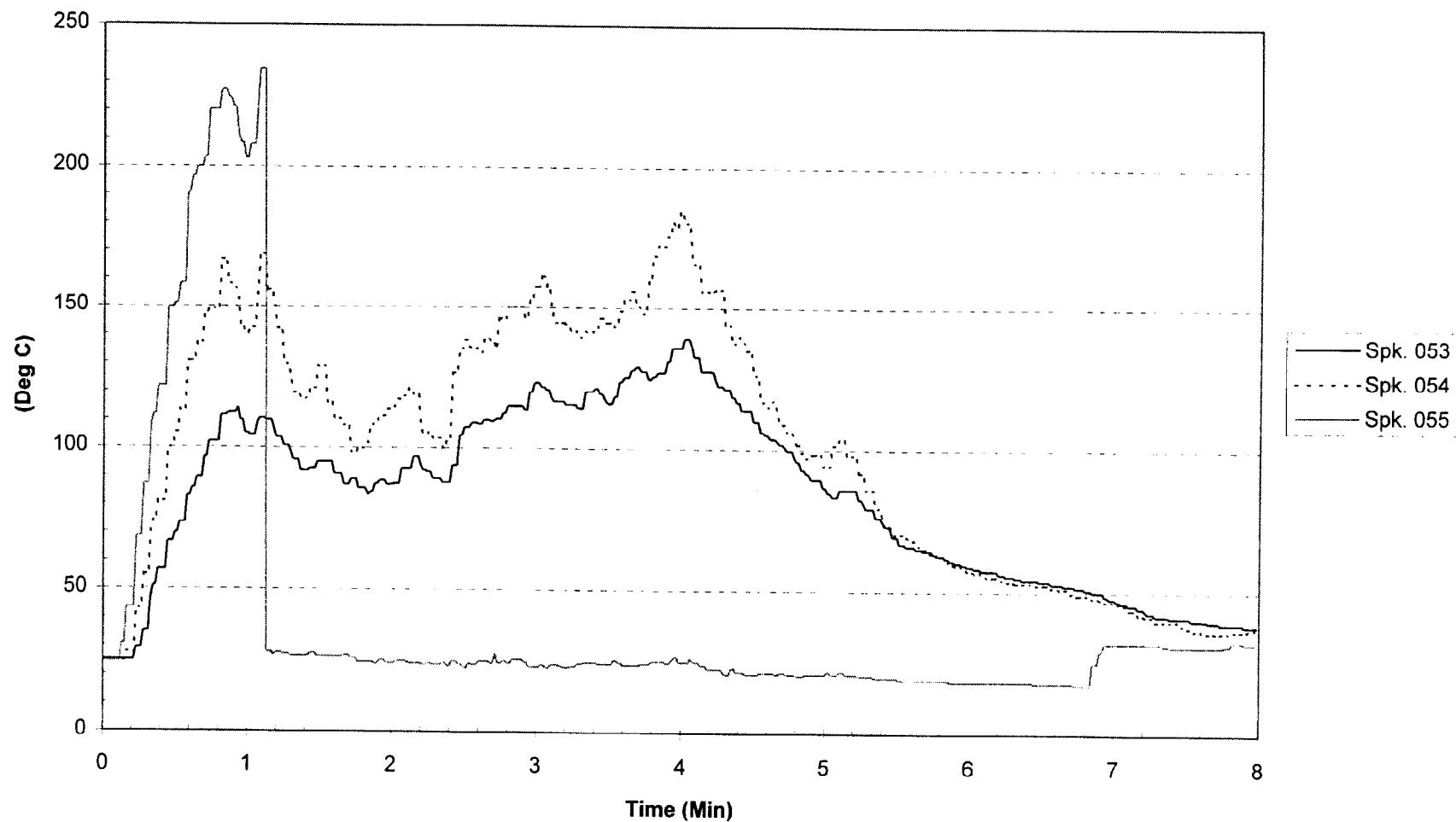
IRI
SP46 - SP48
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

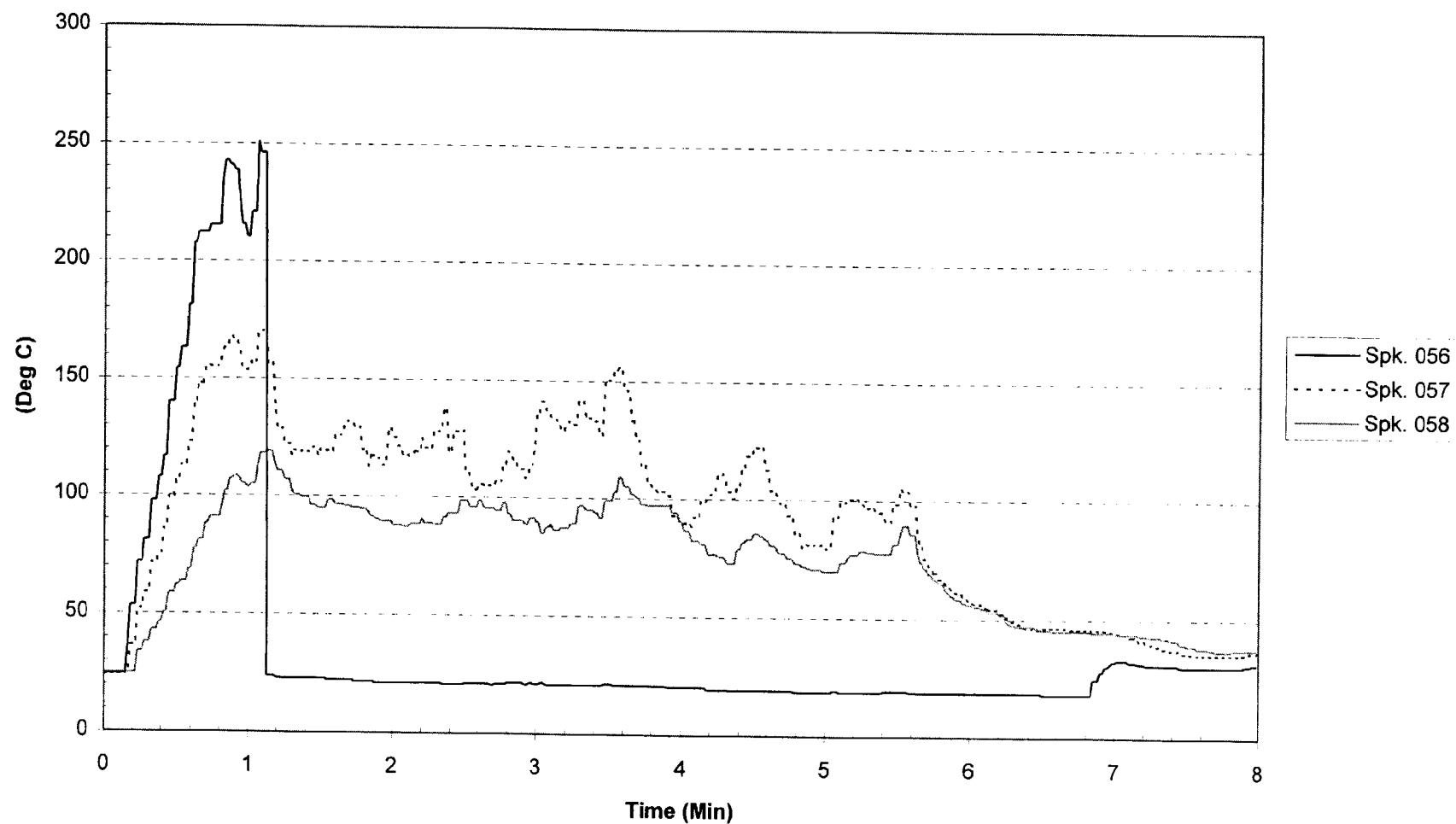
IRI
SP53 - SP55
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

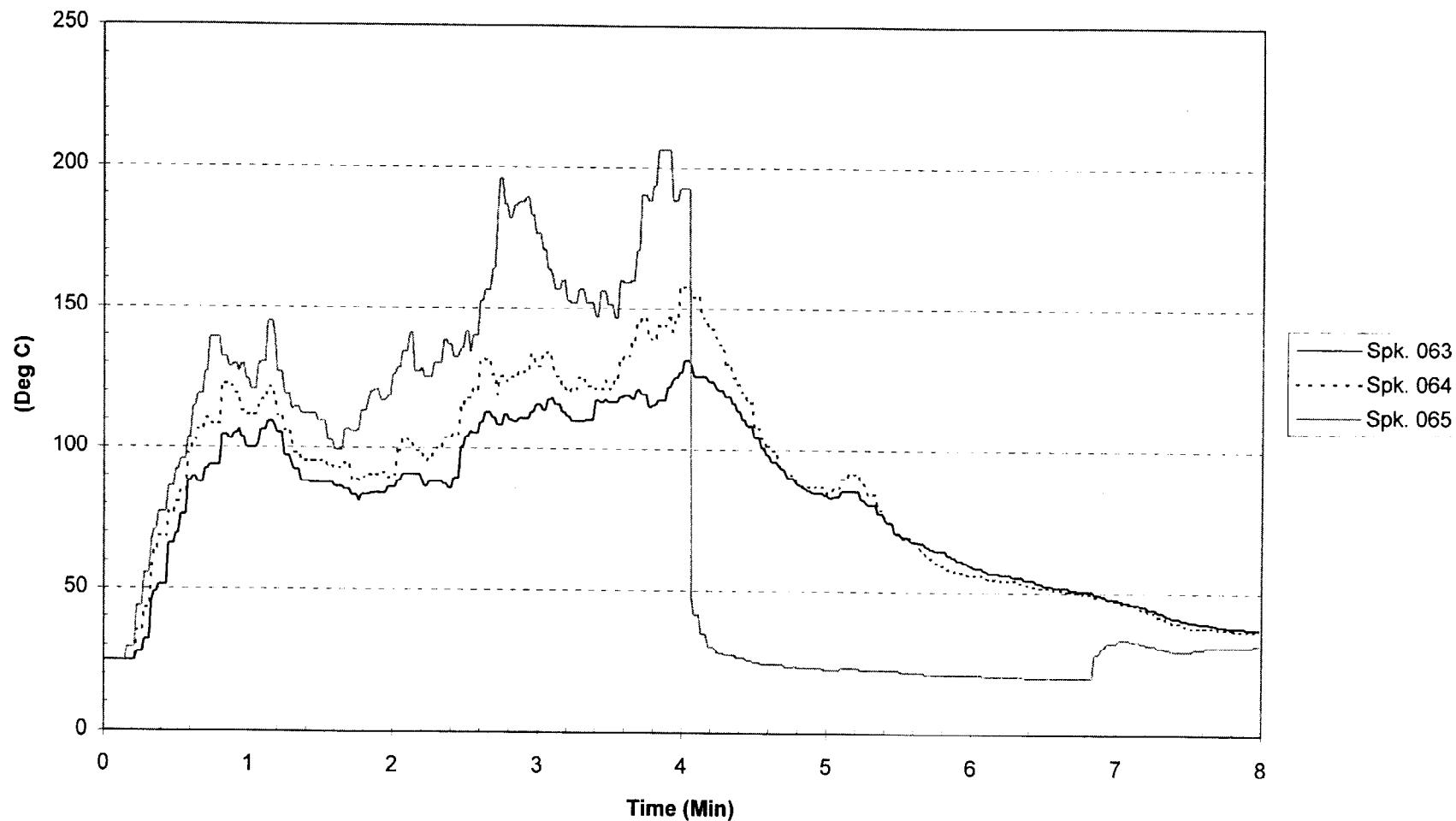
IRI
SP56 - SP58
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

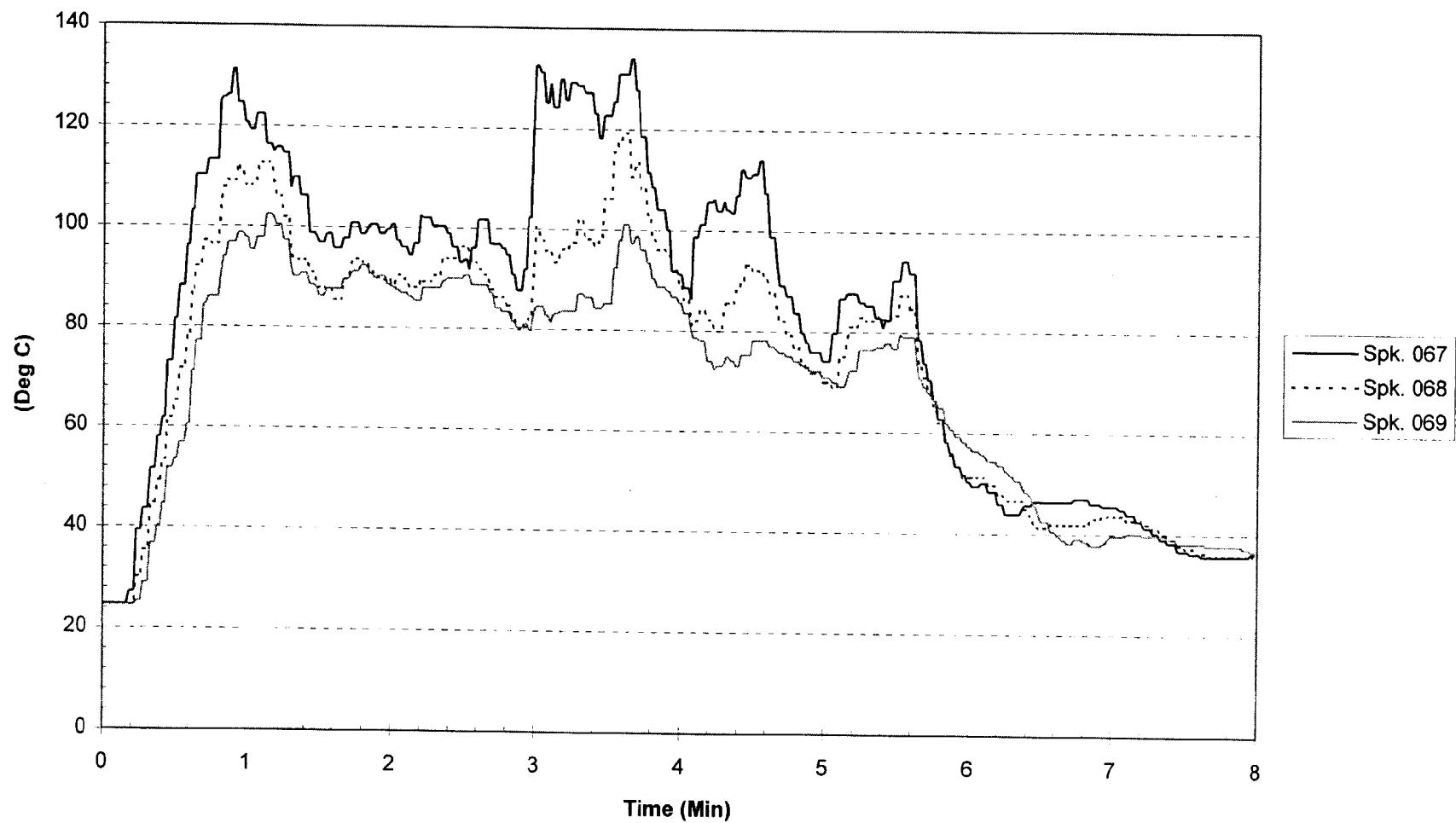
IRI
SP63 - SP65
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

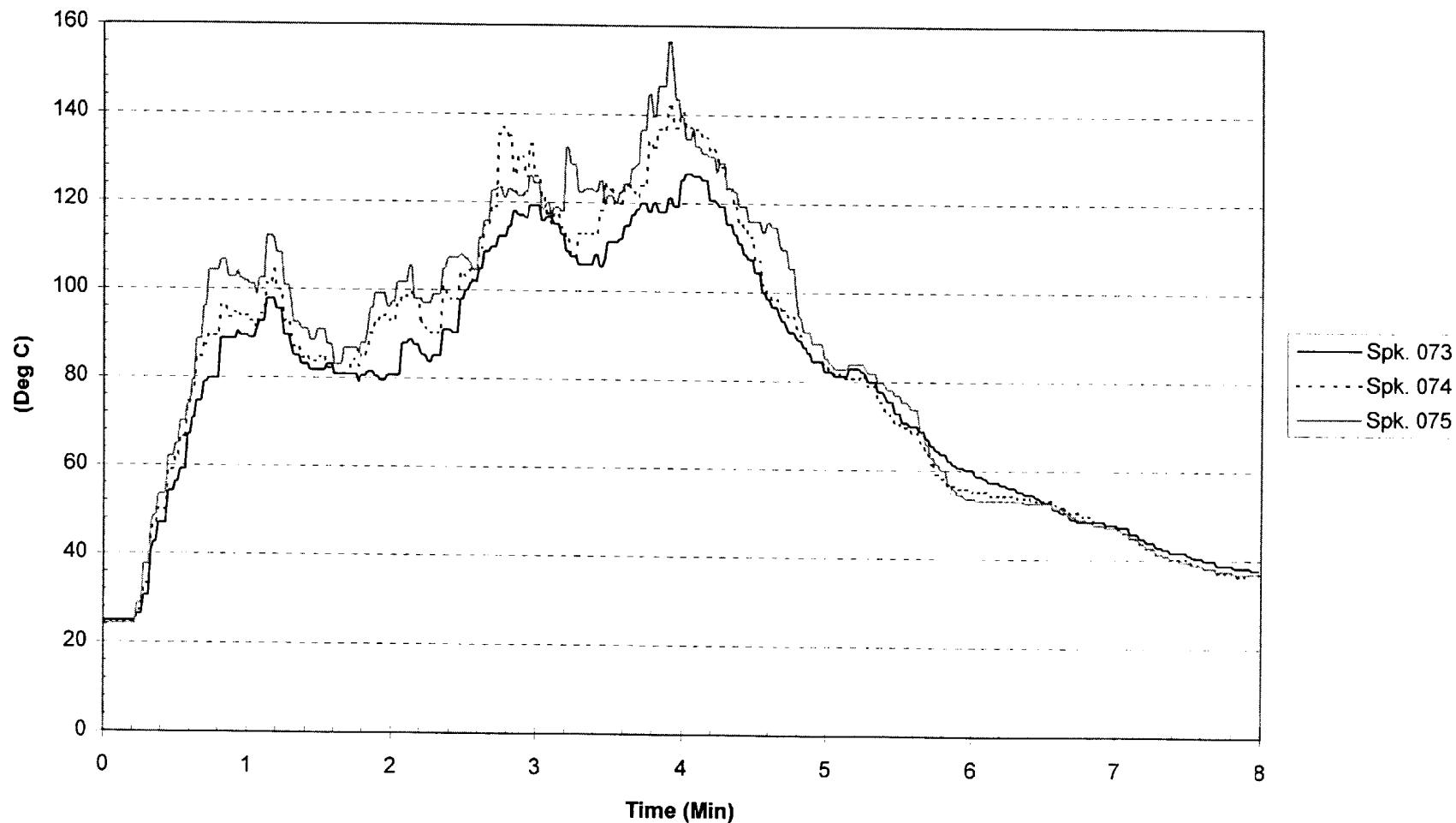
IRI
SP66 - SP68
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

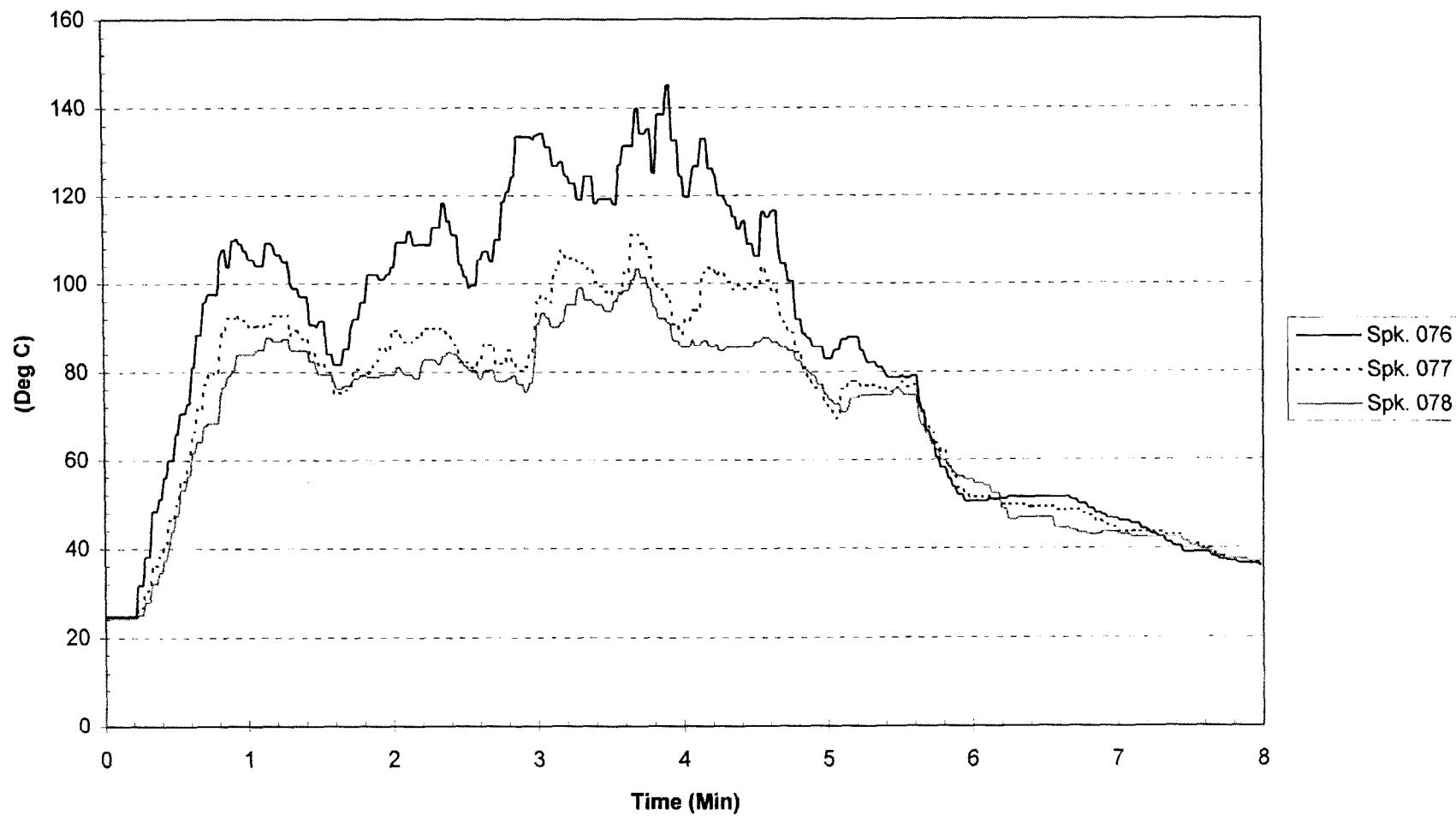
IRI
SP73 - SP75
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

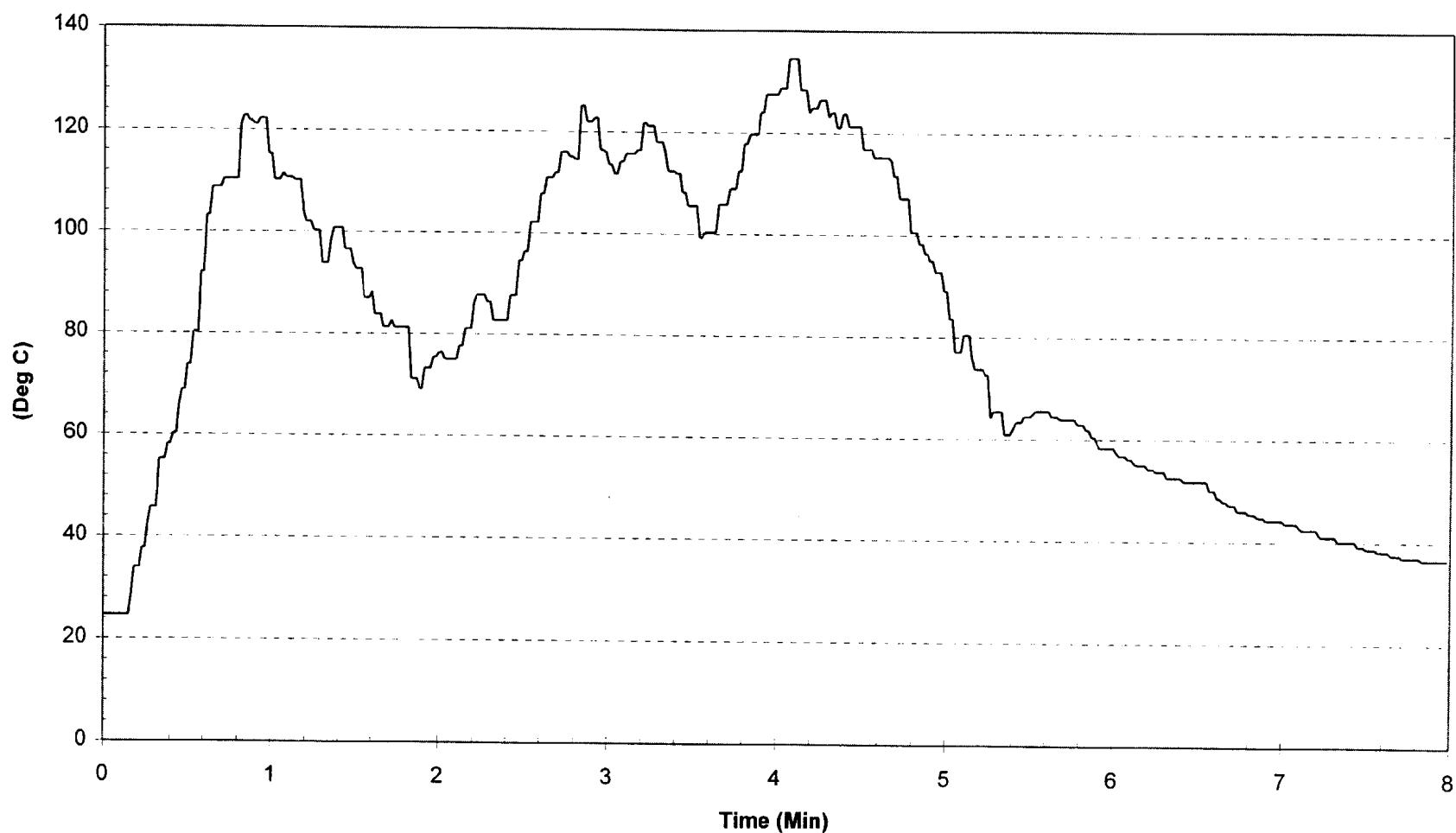
IRI
SP76 - SP78
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

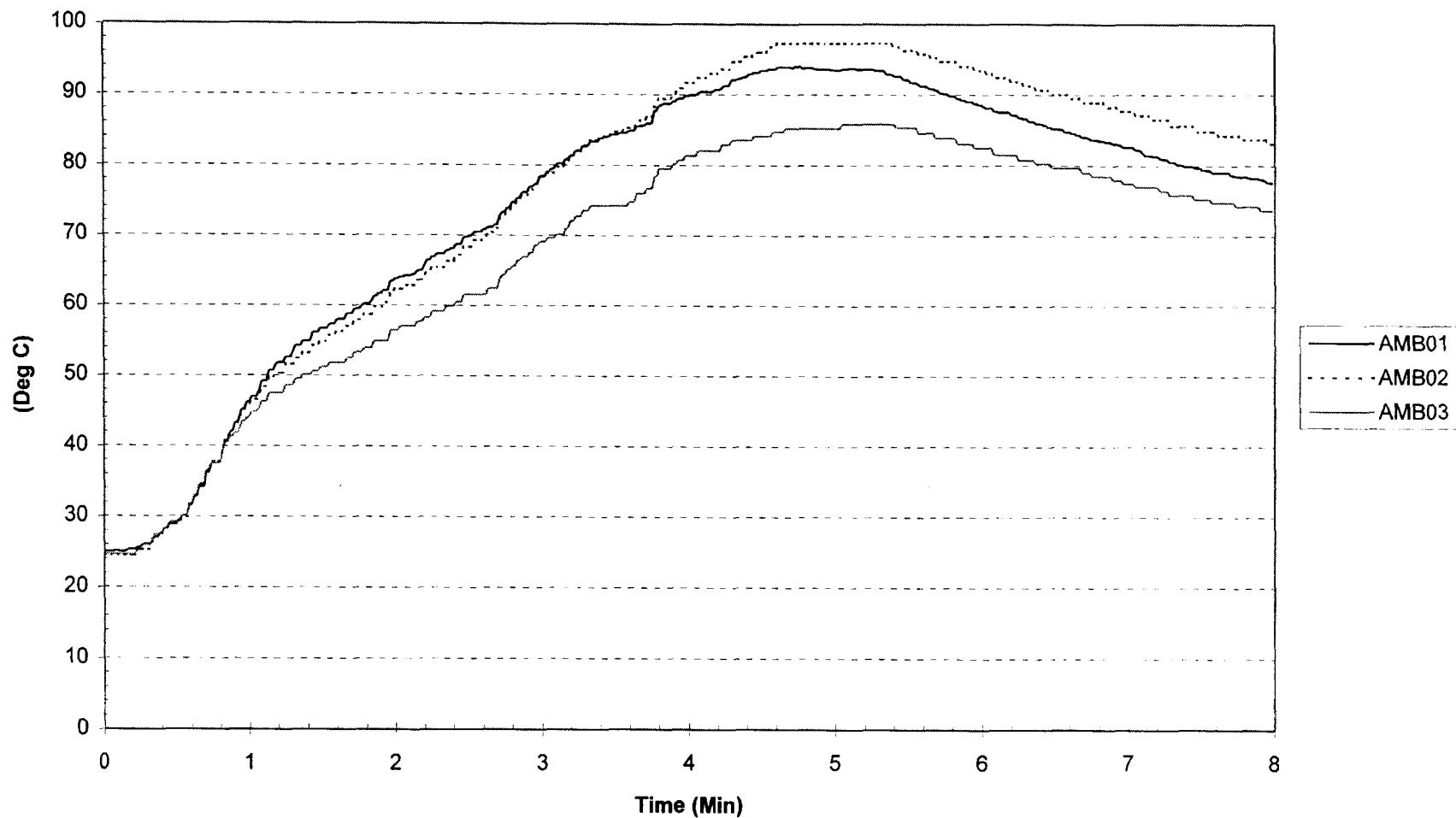
IRI
AIR ABOVE IGNITION
4 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

IRI
STEEL ABOVE IGNITION
4 GPM RUNNING HEPTANE FUEL FIRE

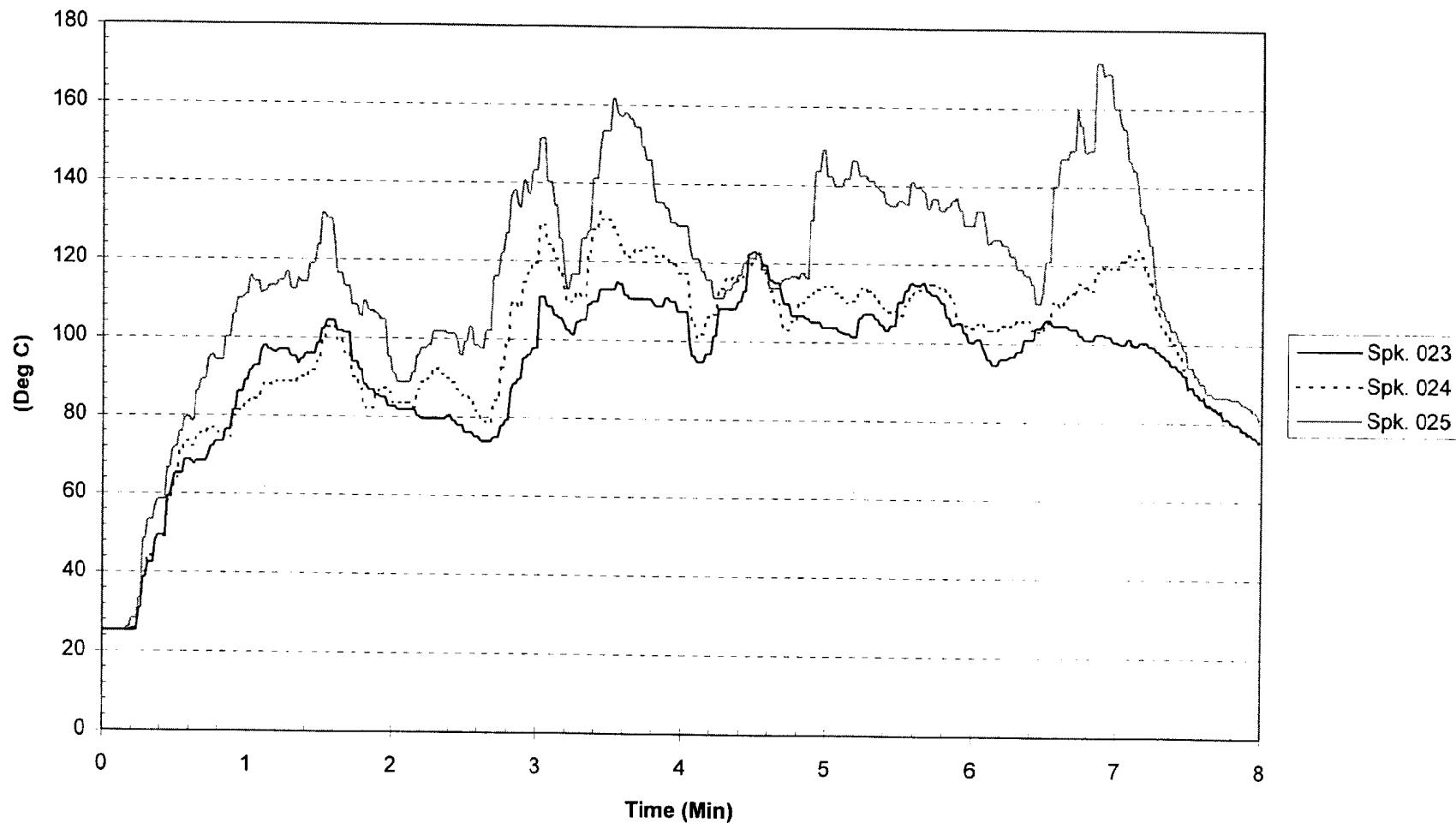


NC1838/97NK34585
Test Date : 10/9/97

10099701.BD1

APPENDIX B
Fire Test No. 2

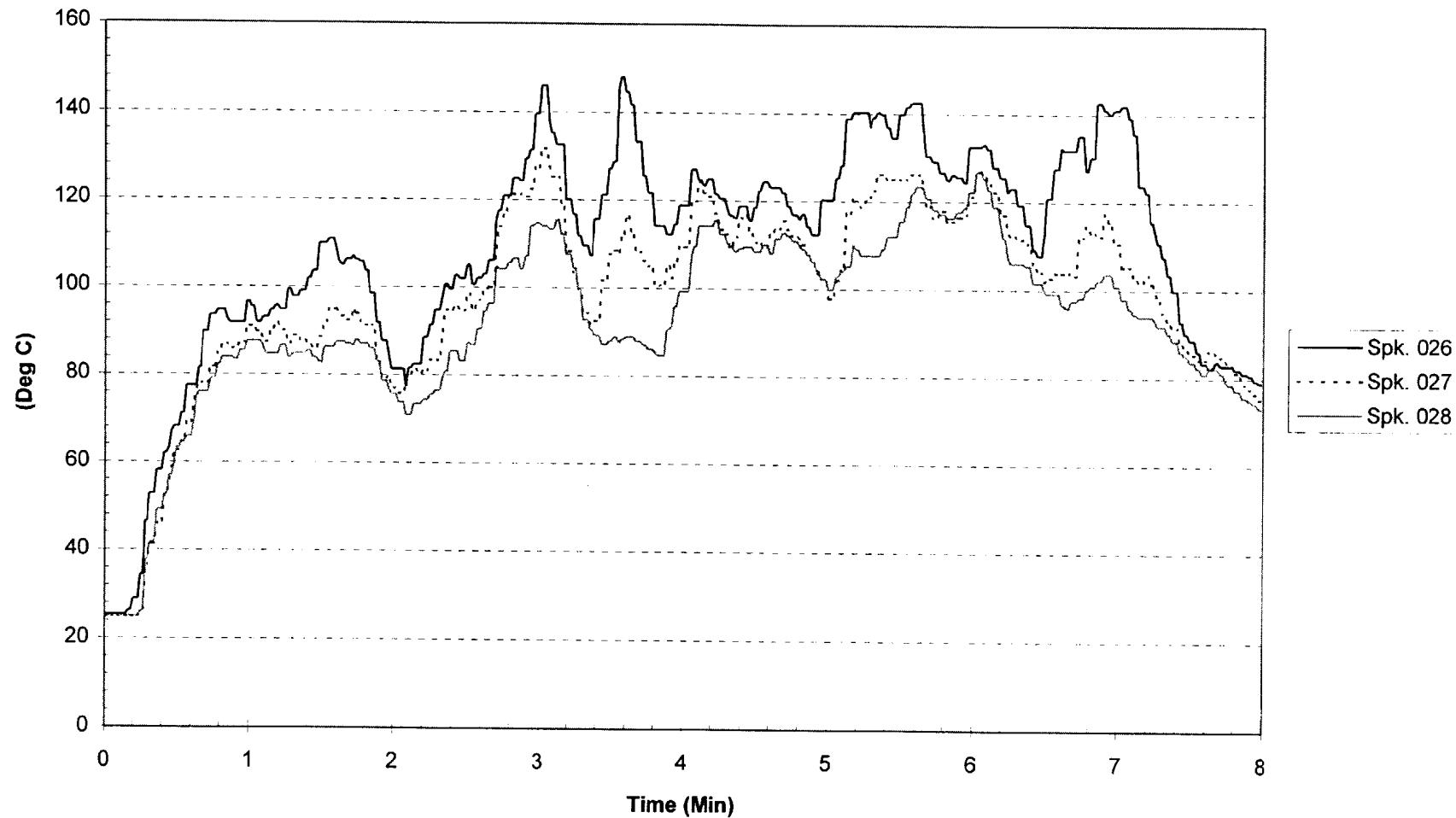
IRI
SP23 - SP25
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

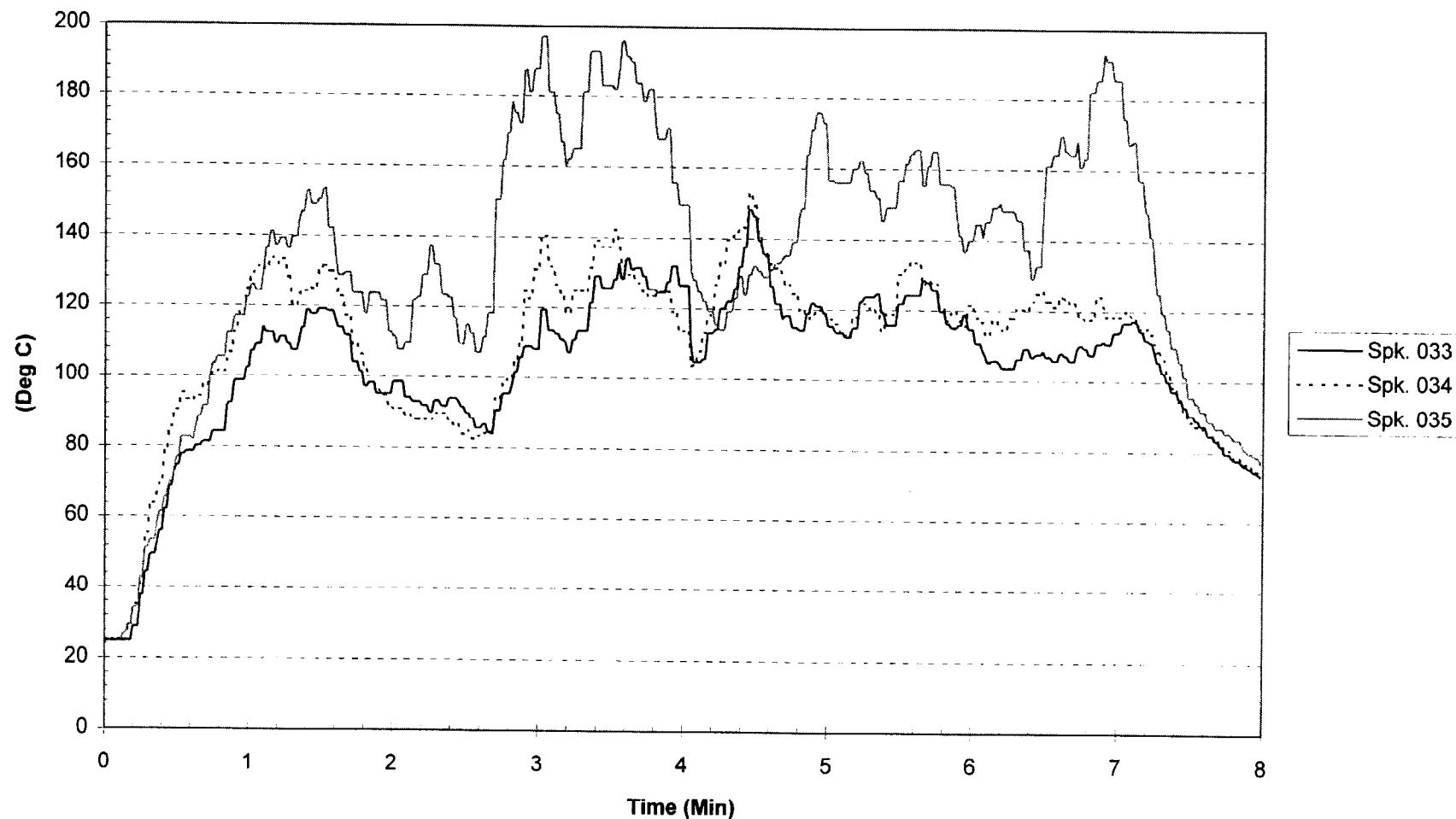
IRI
SP26 - SP28
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

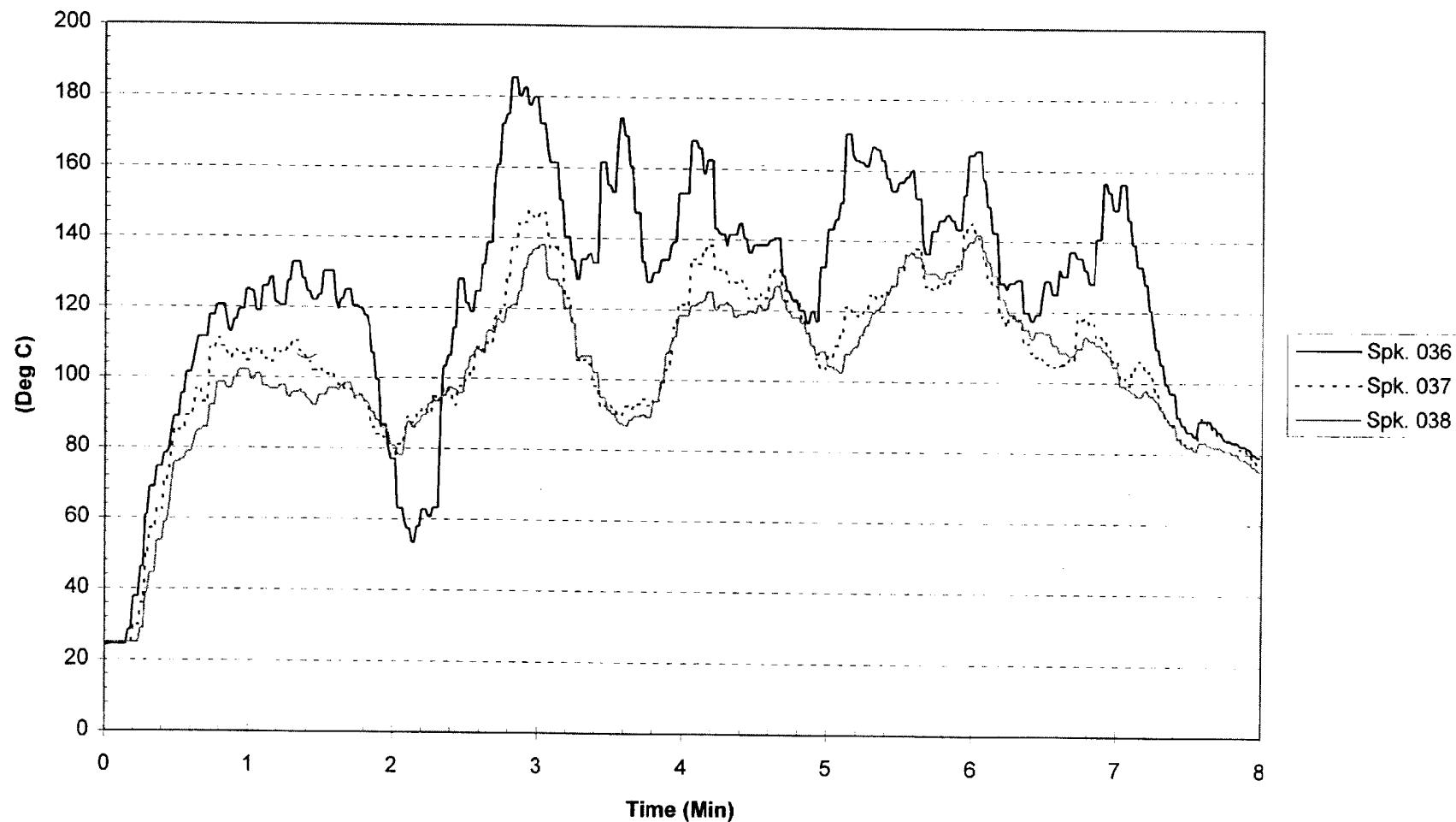
IRI
SP33 - SP35
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

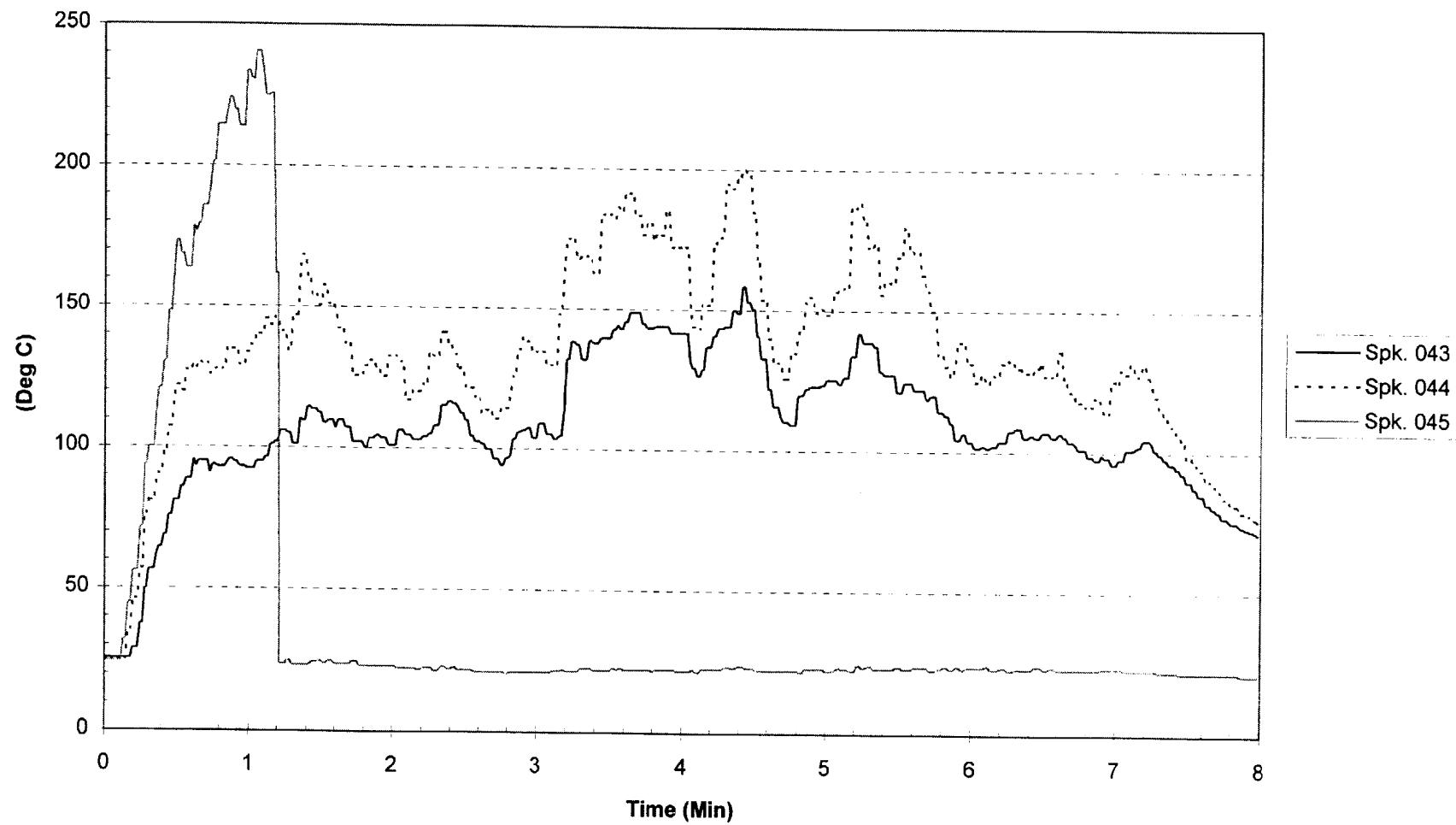
IRI
SP36 - SP38
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

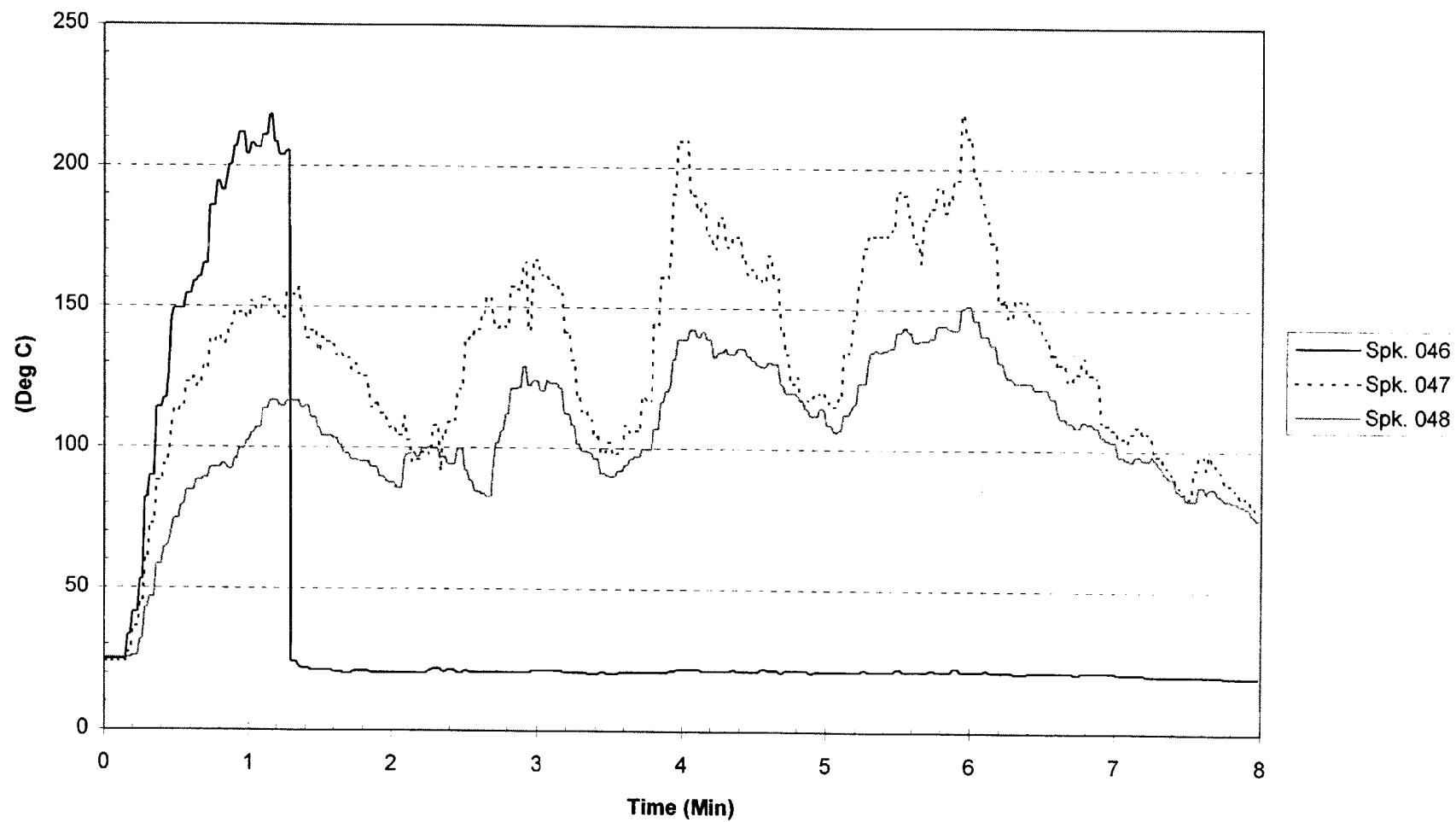
IRI
SP43 - SP45
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

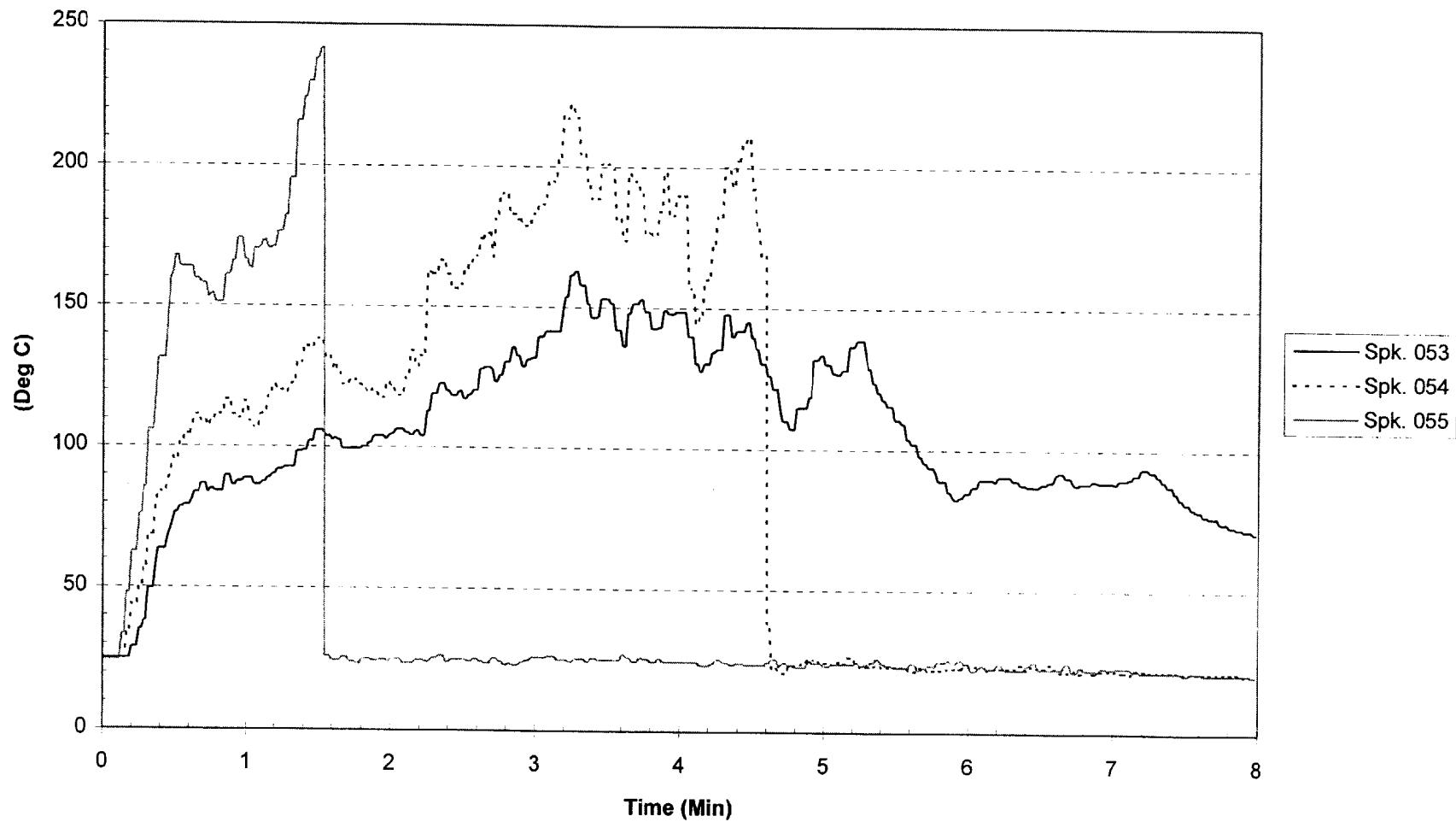
IRI
SP46 - SP48
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

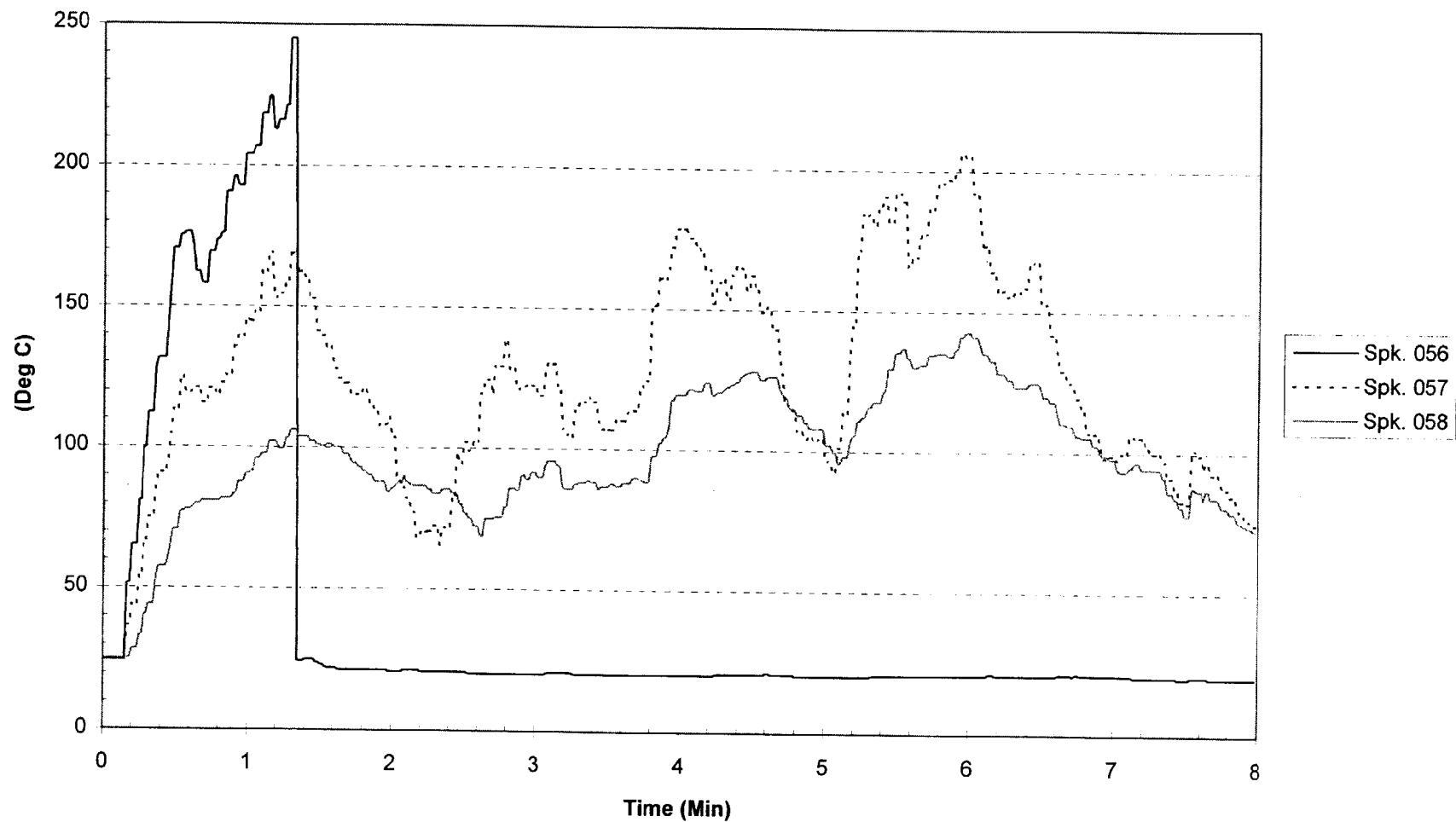
IRI
SP53 - SP55
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

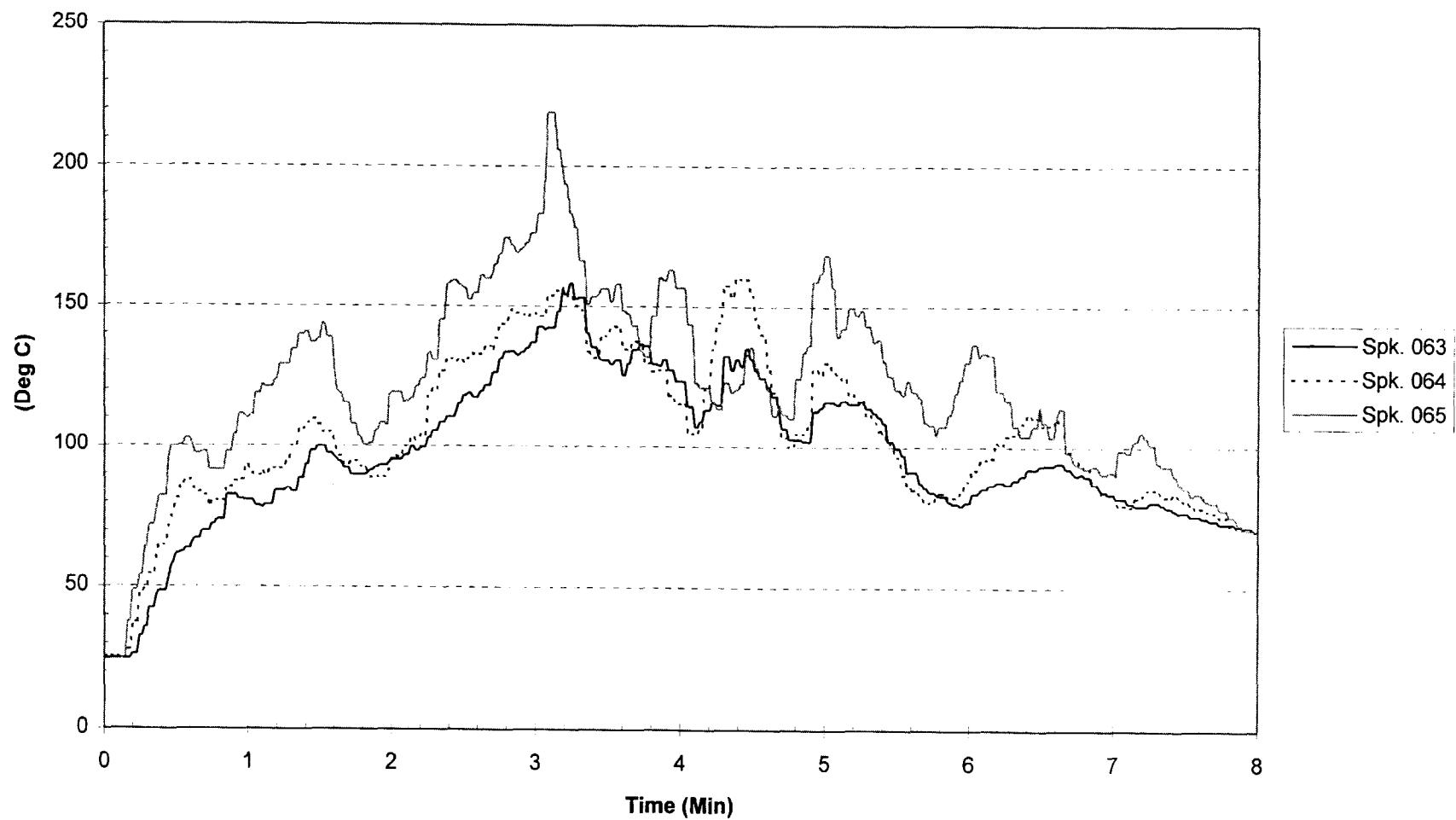
IRI
SP56 - SP58
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

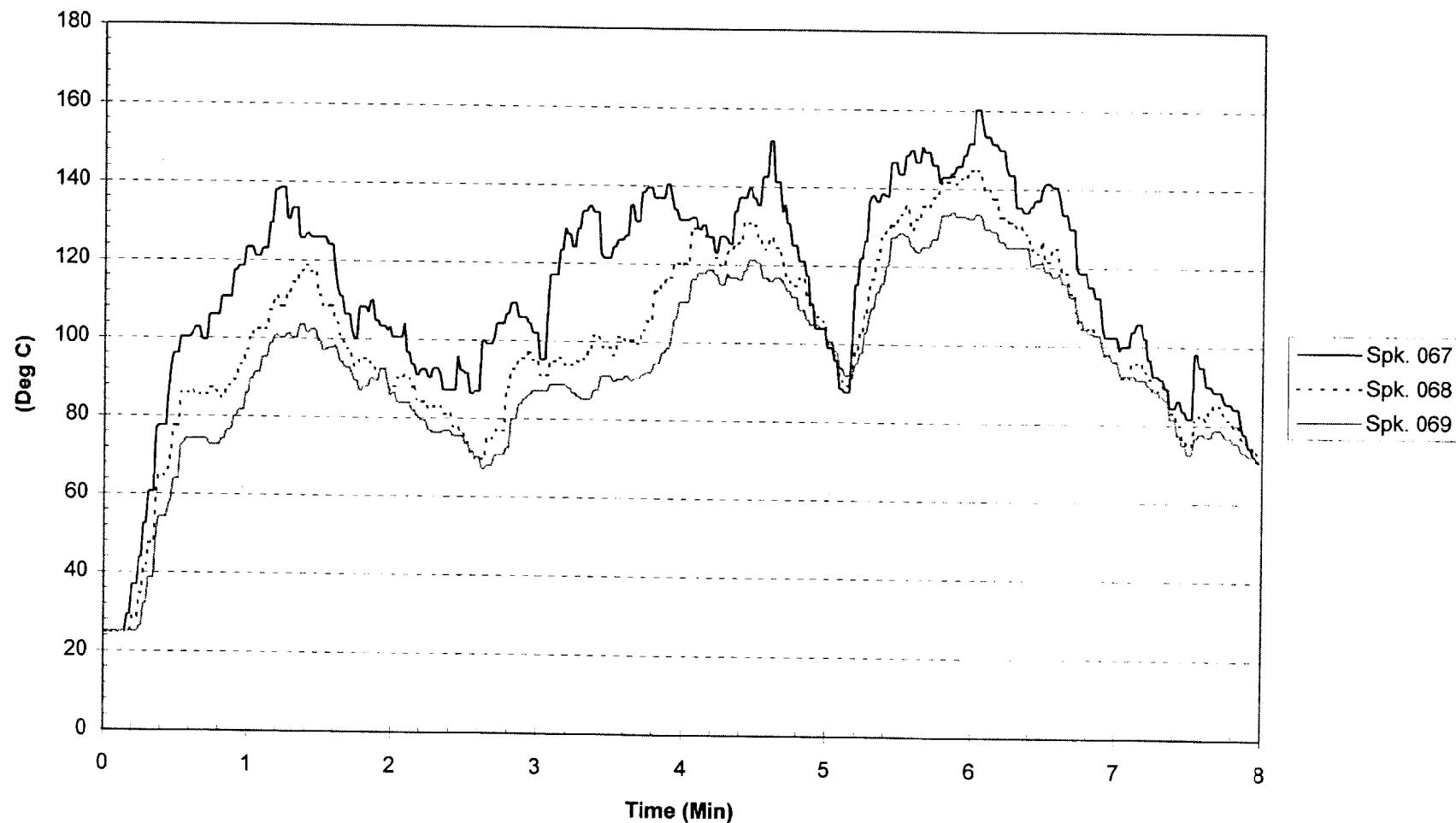
IRI
SP63 - SP65
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

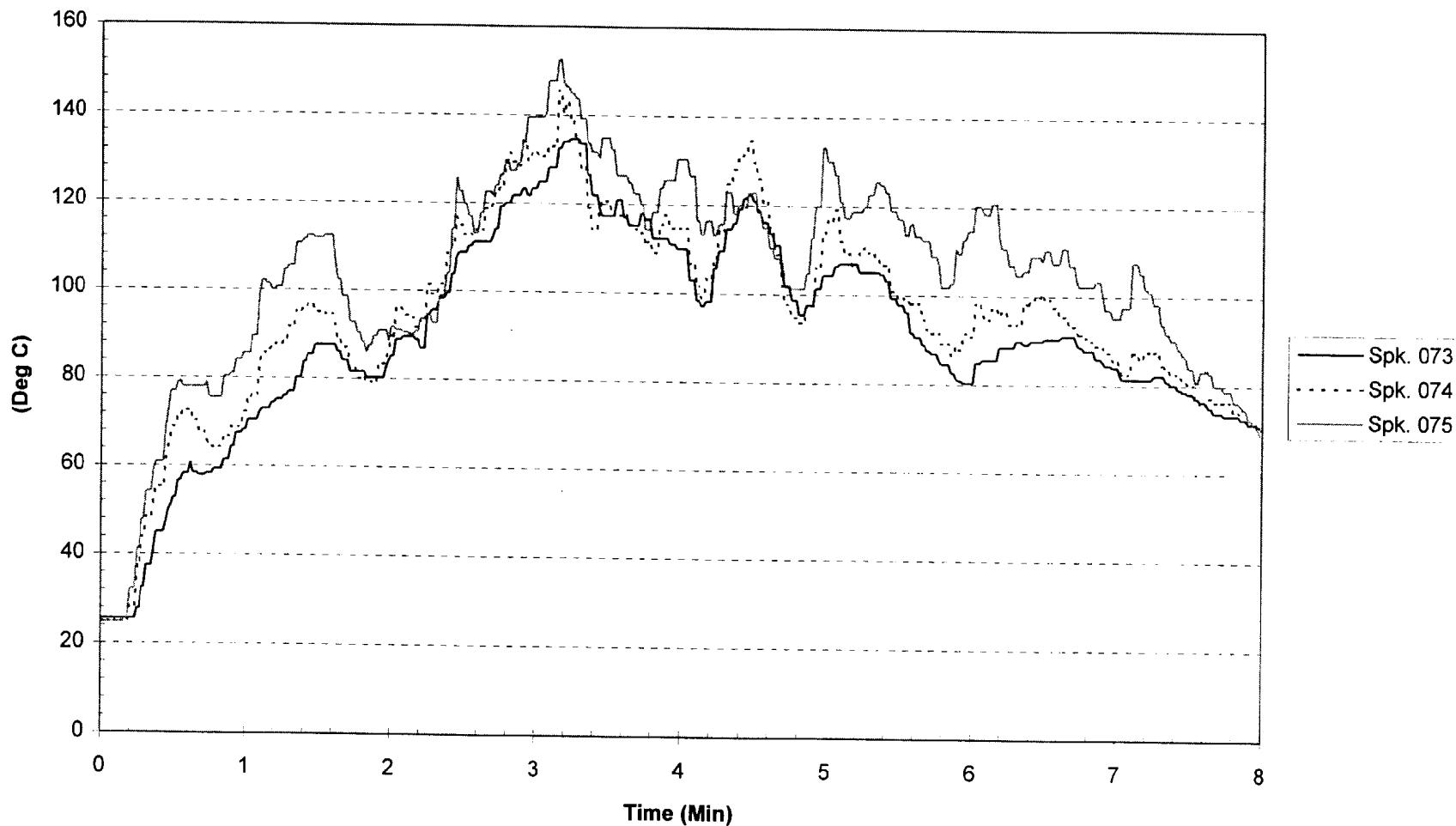
IRI
SP66 - SP68
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

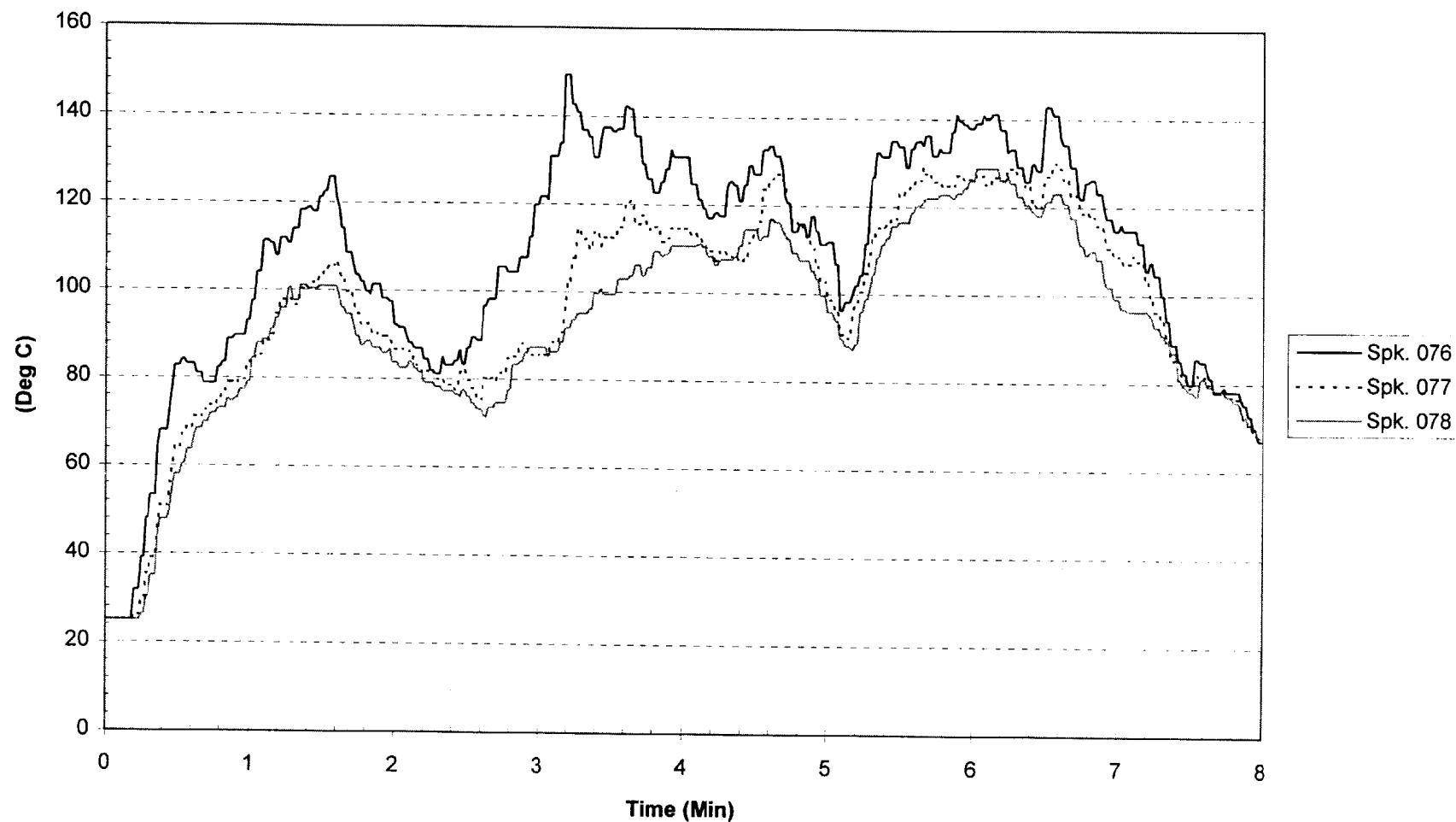
IRI
SP73 - SP75
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

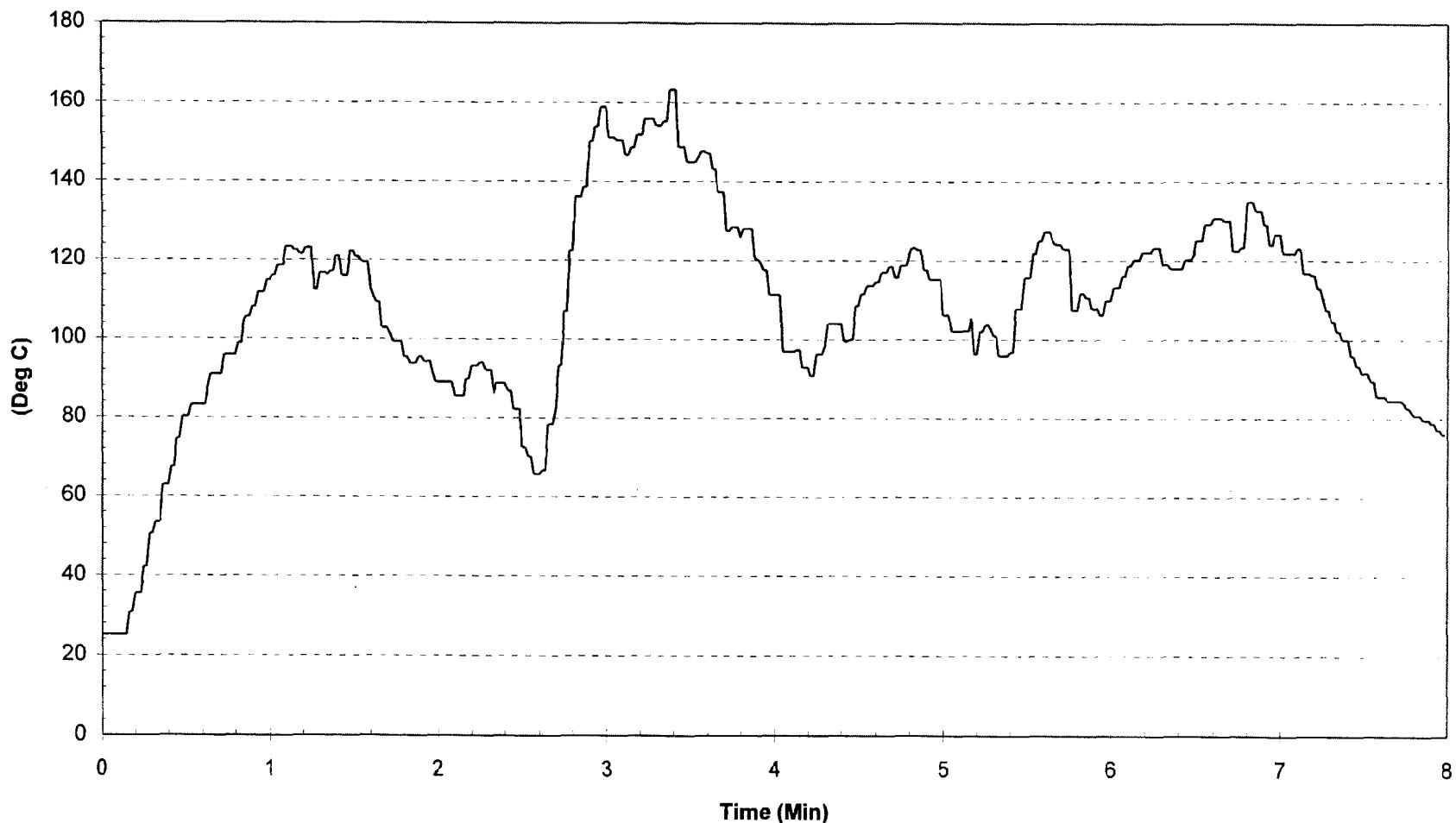
IRI
SP76 - SP78
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

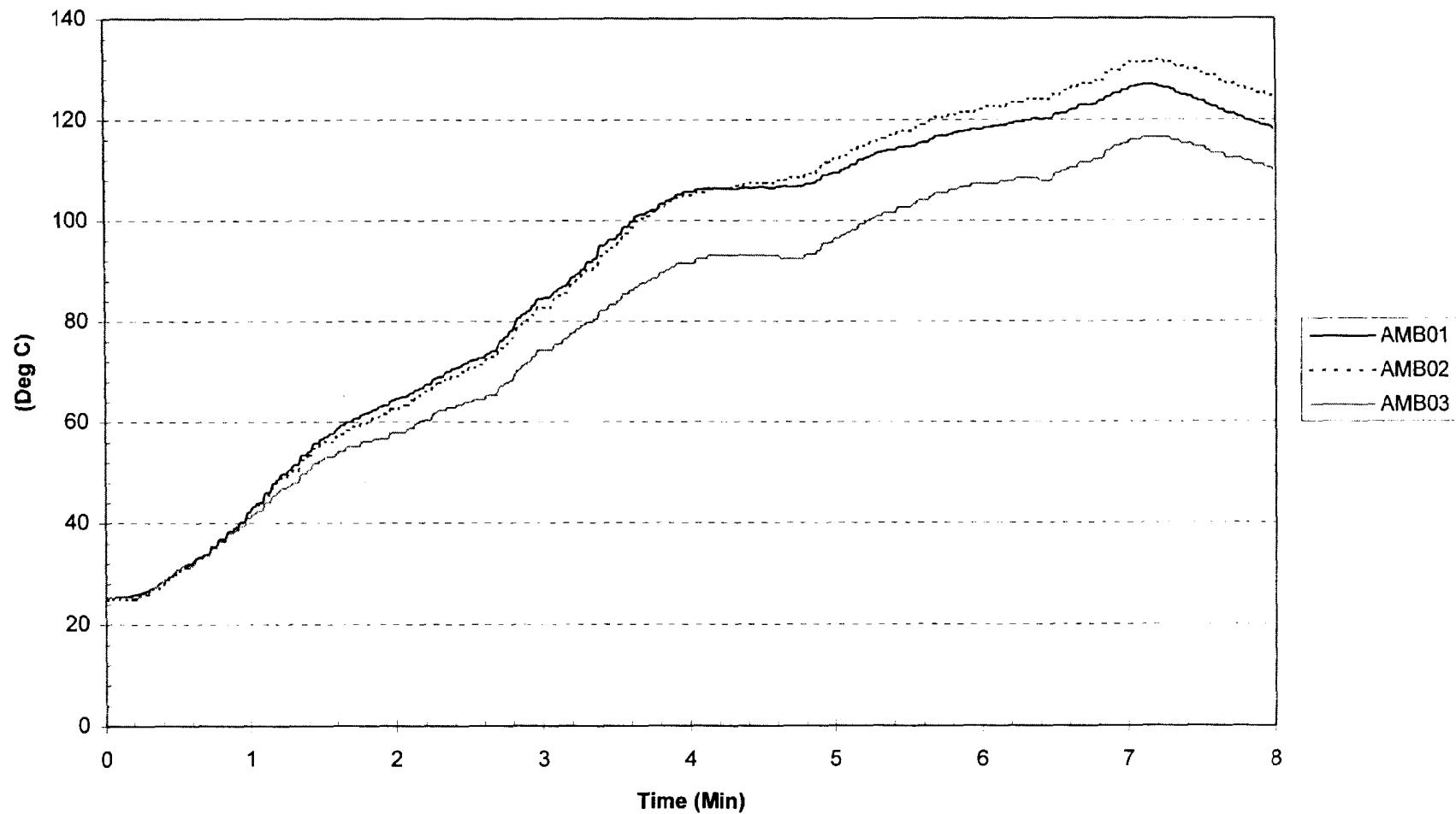
IRI
AIR ABOVE IGNITION
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

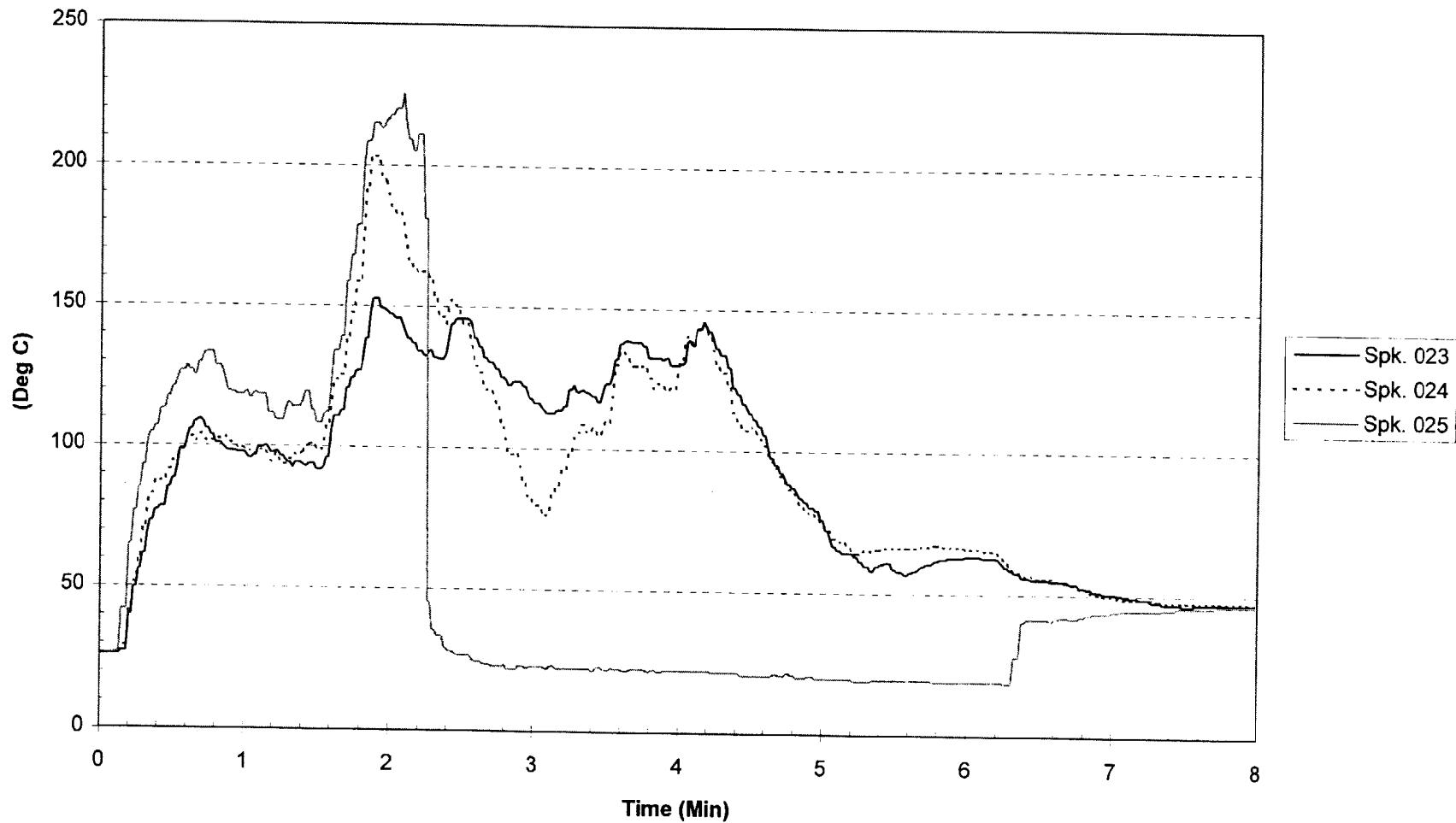
IRI
STEEL ABOVE IGNITION
6 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099702.BD1

IRI
SP23 - SP25
15 GPM RUNNING HEPTANE FUEL FIRE

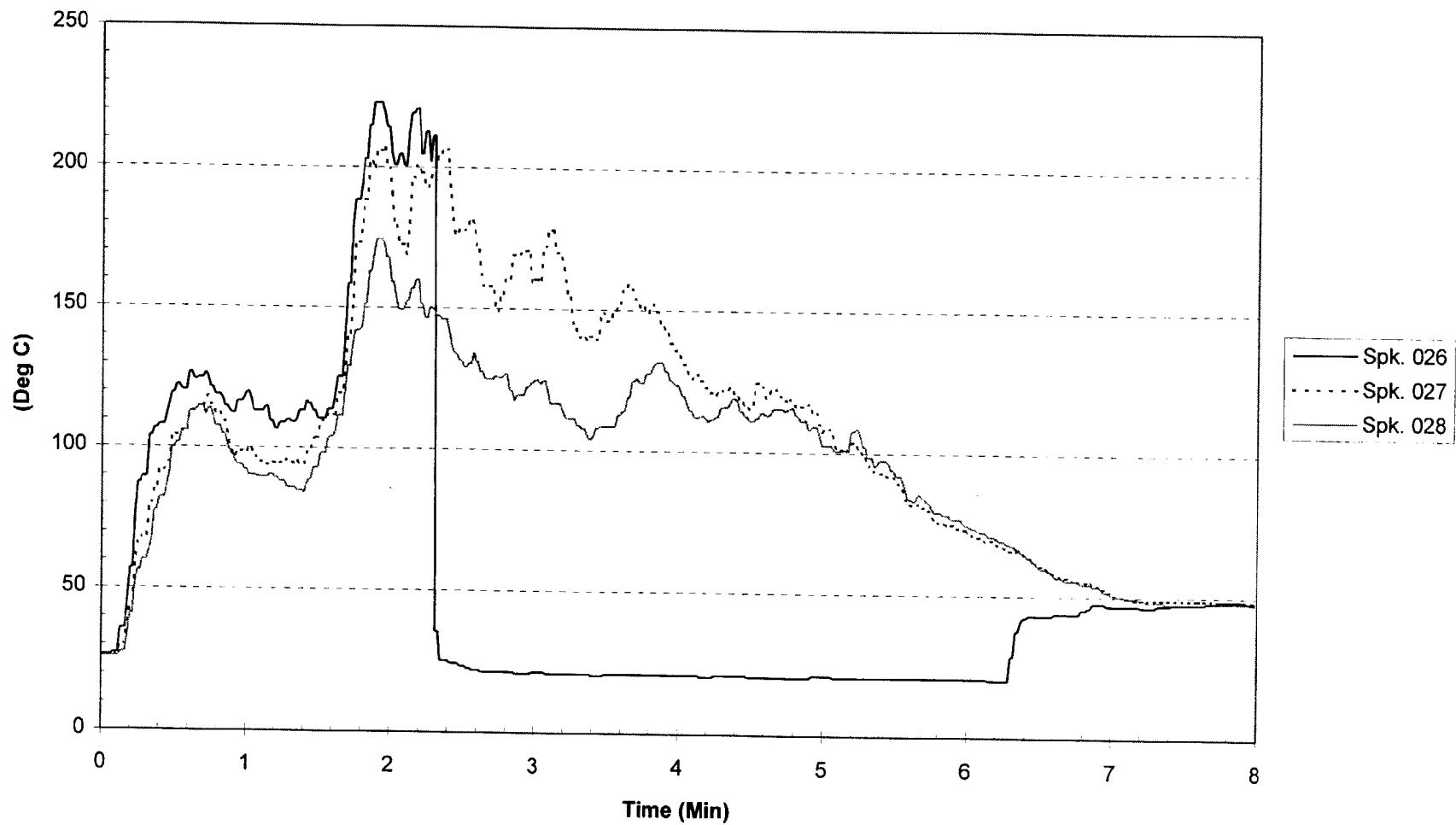


NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

APPENDIX C
Fire Test No. 3

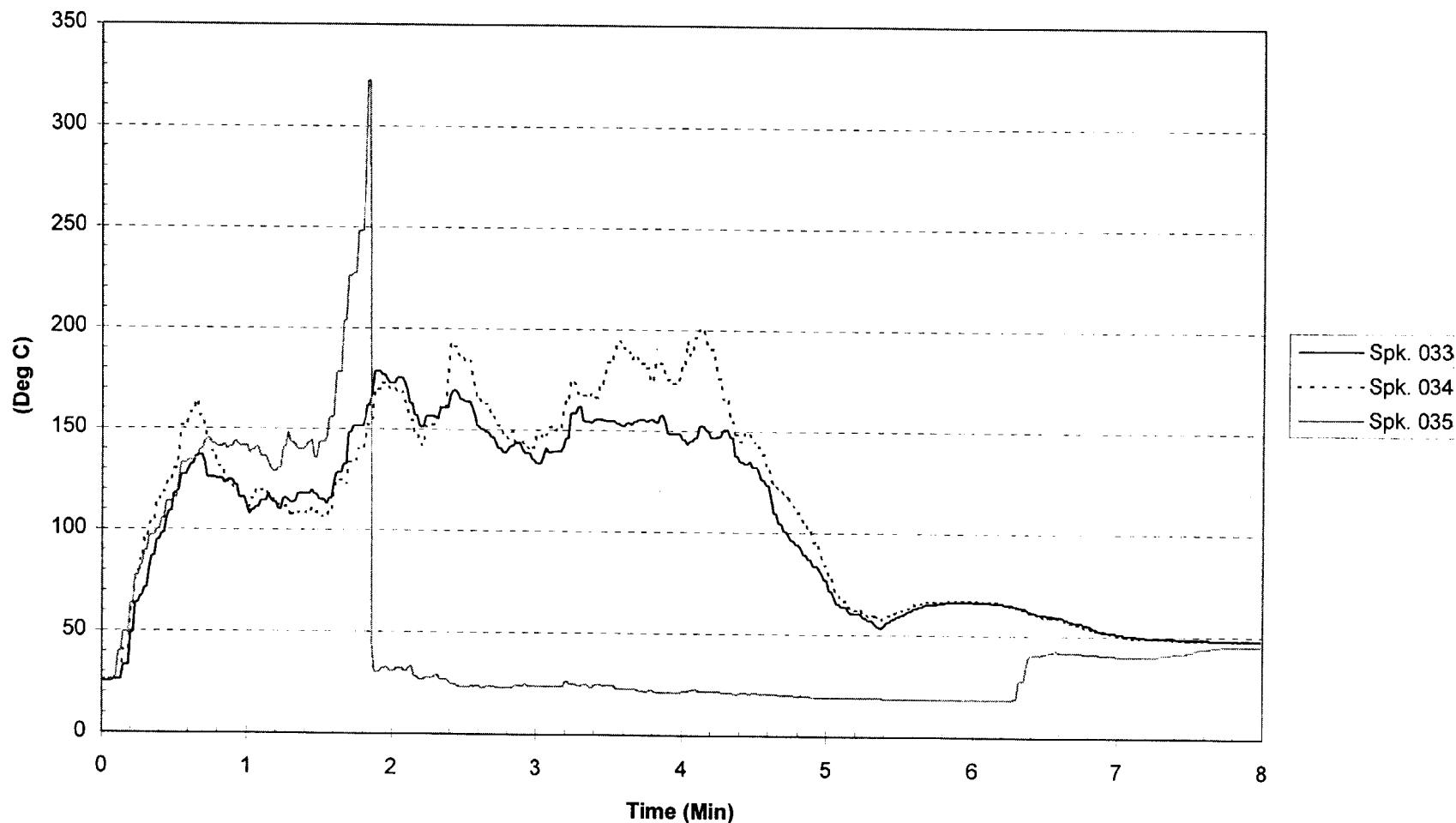
IRI
SP26 - SP28
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

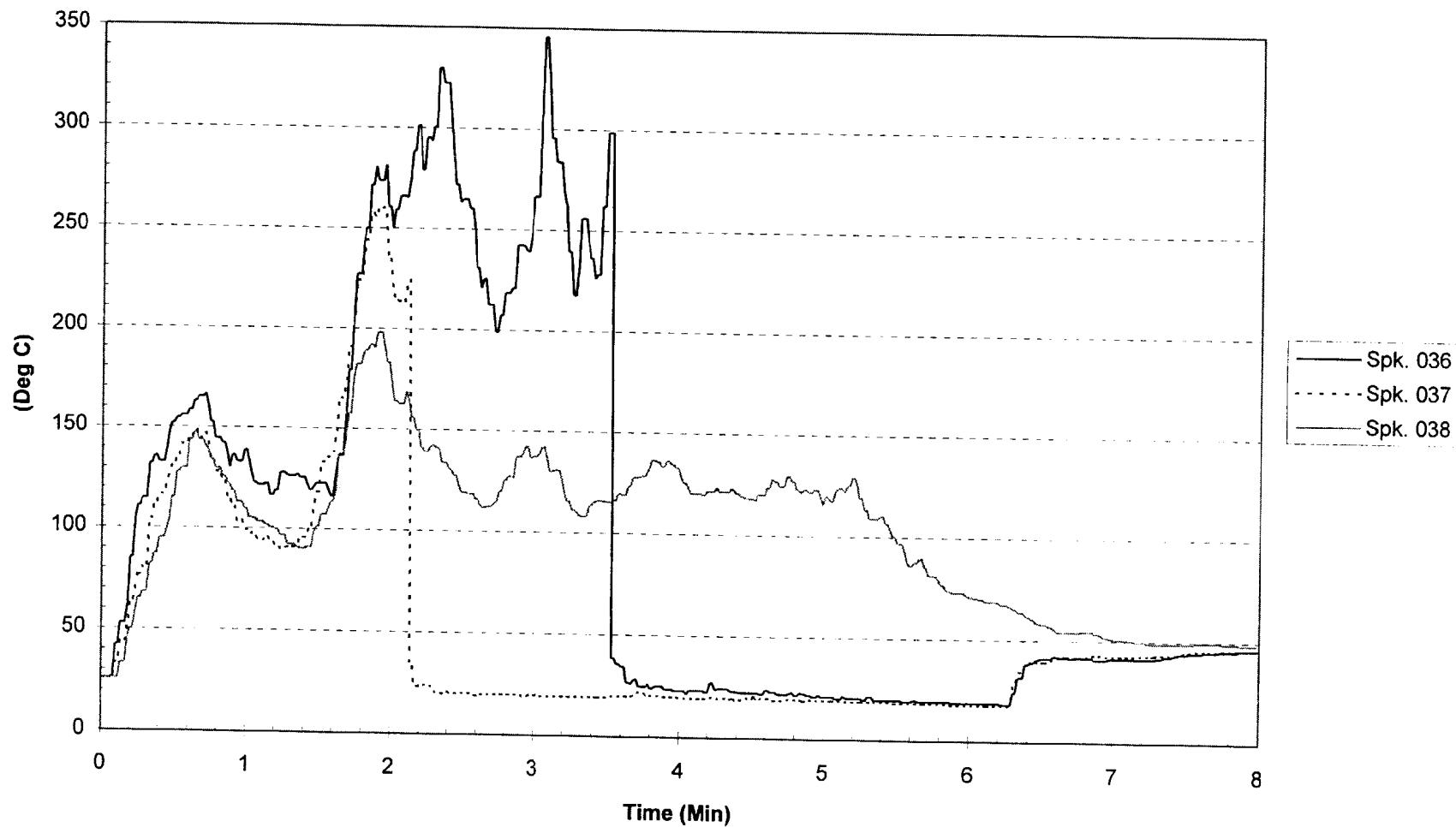
IRI
SP33 - SP35
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

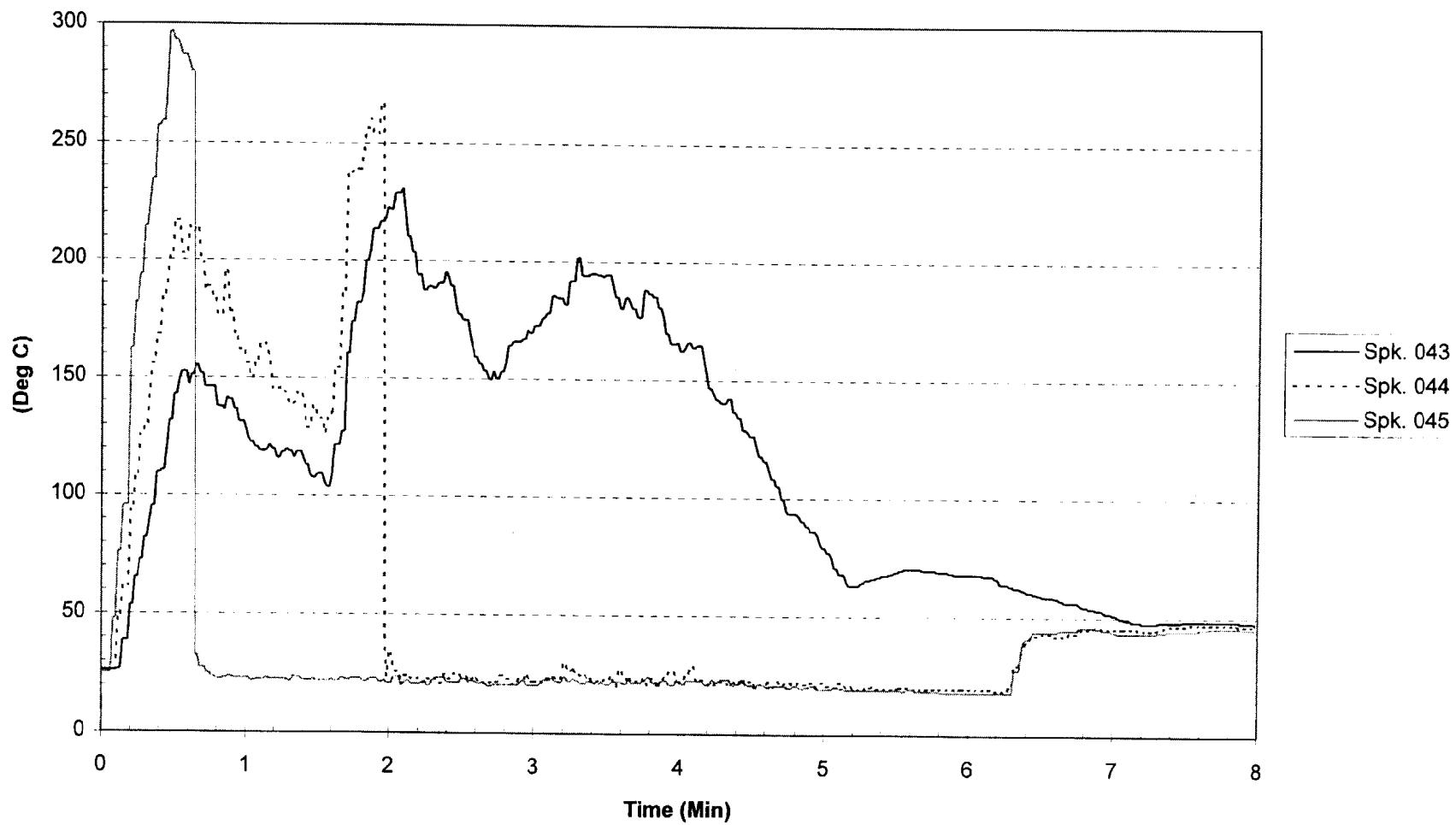
IRI
SP36 - SP38
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

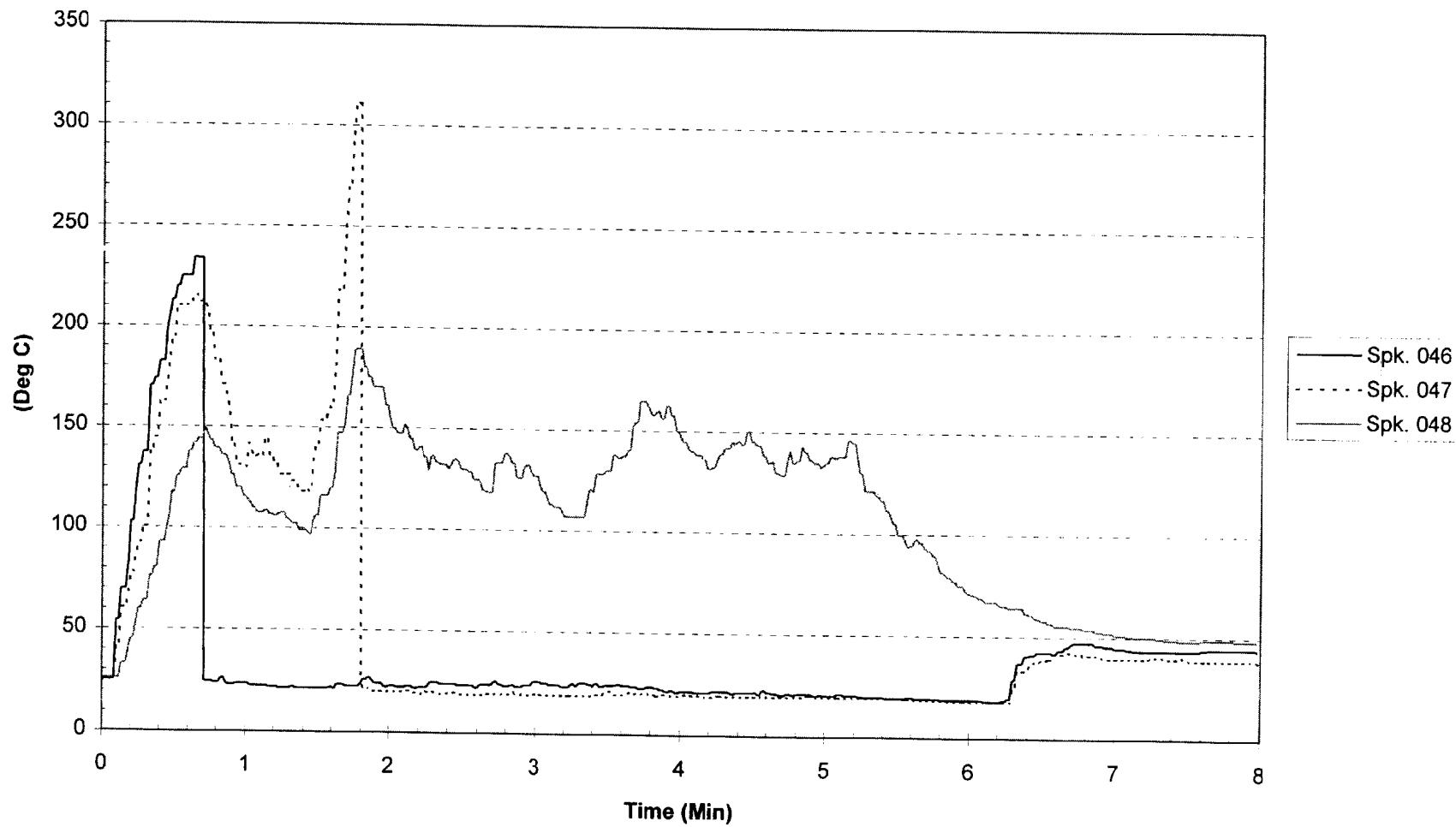
IRI
SP43 - SP45
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

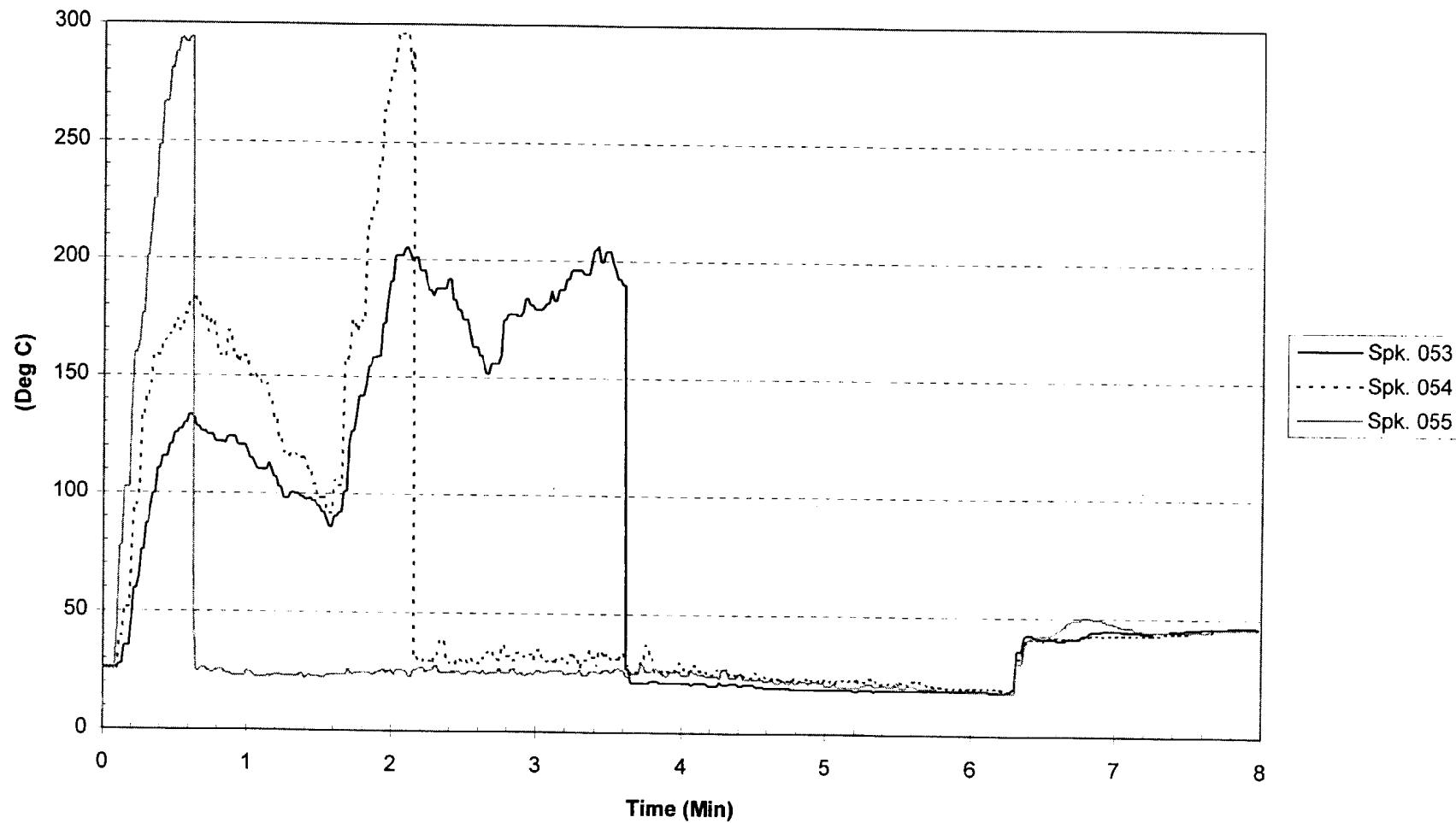
IRI
SP46 - SP48
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

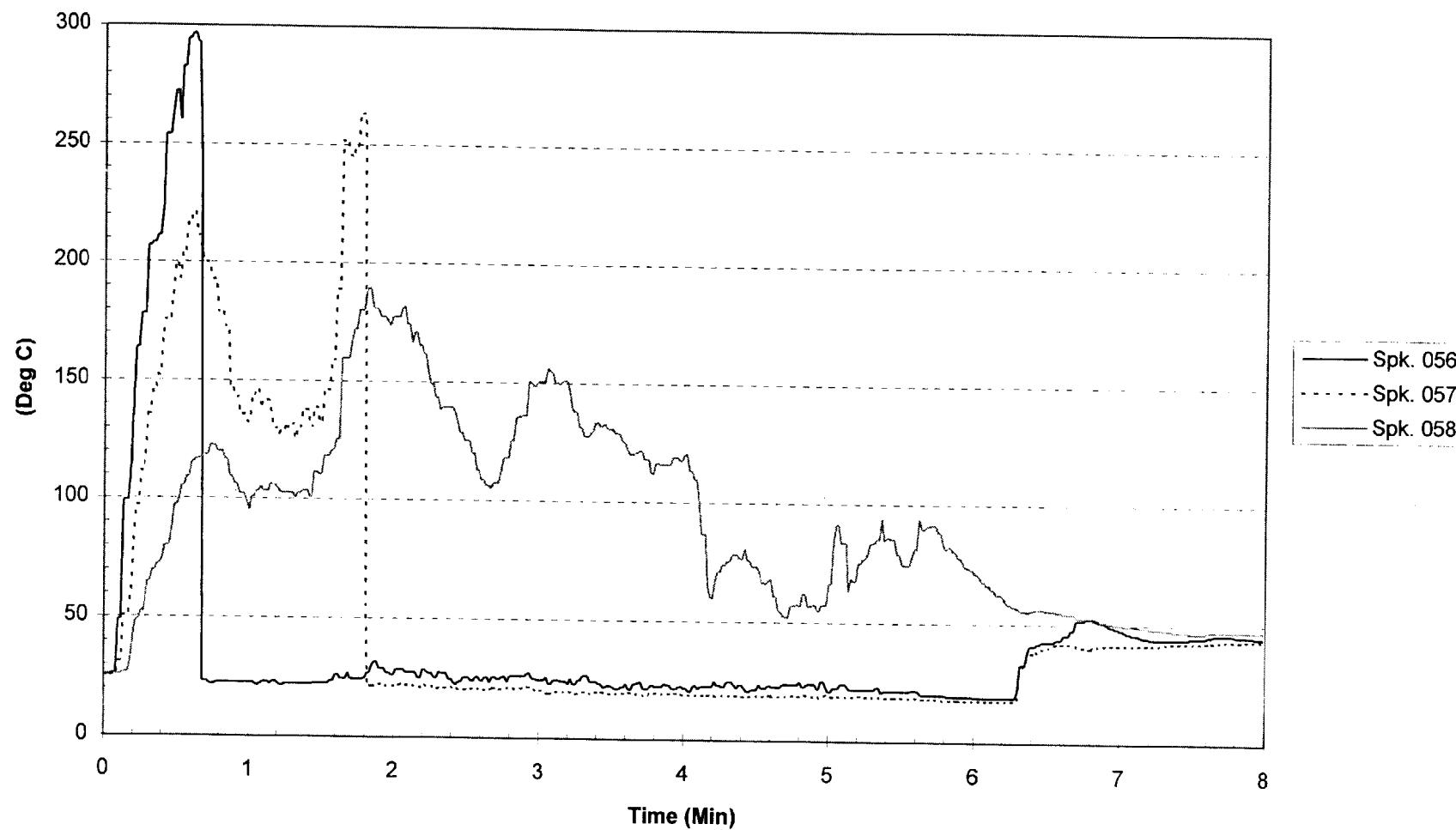
IRI
SP53 - SP55
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

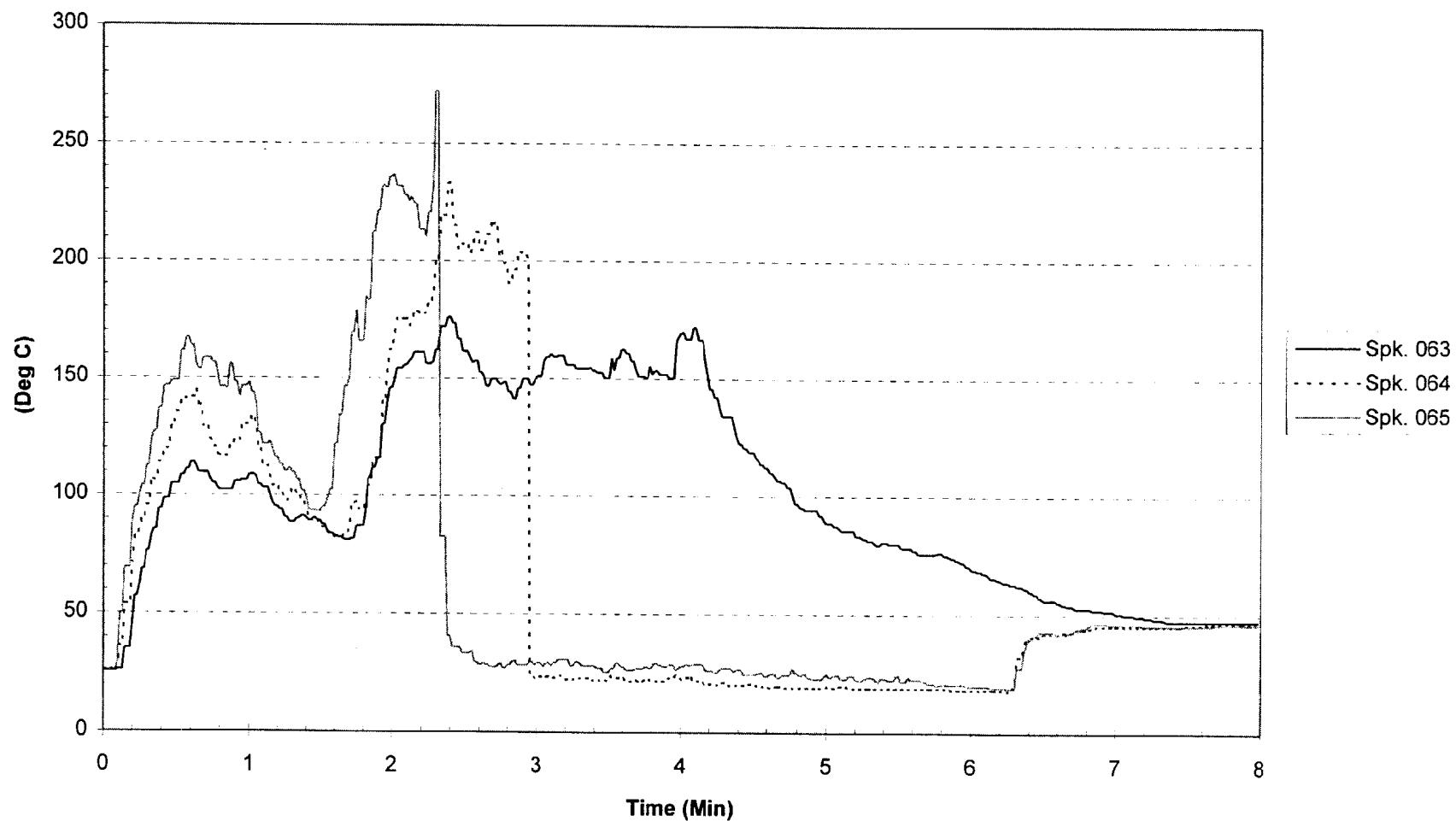
IRI
SP56 - SP58
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

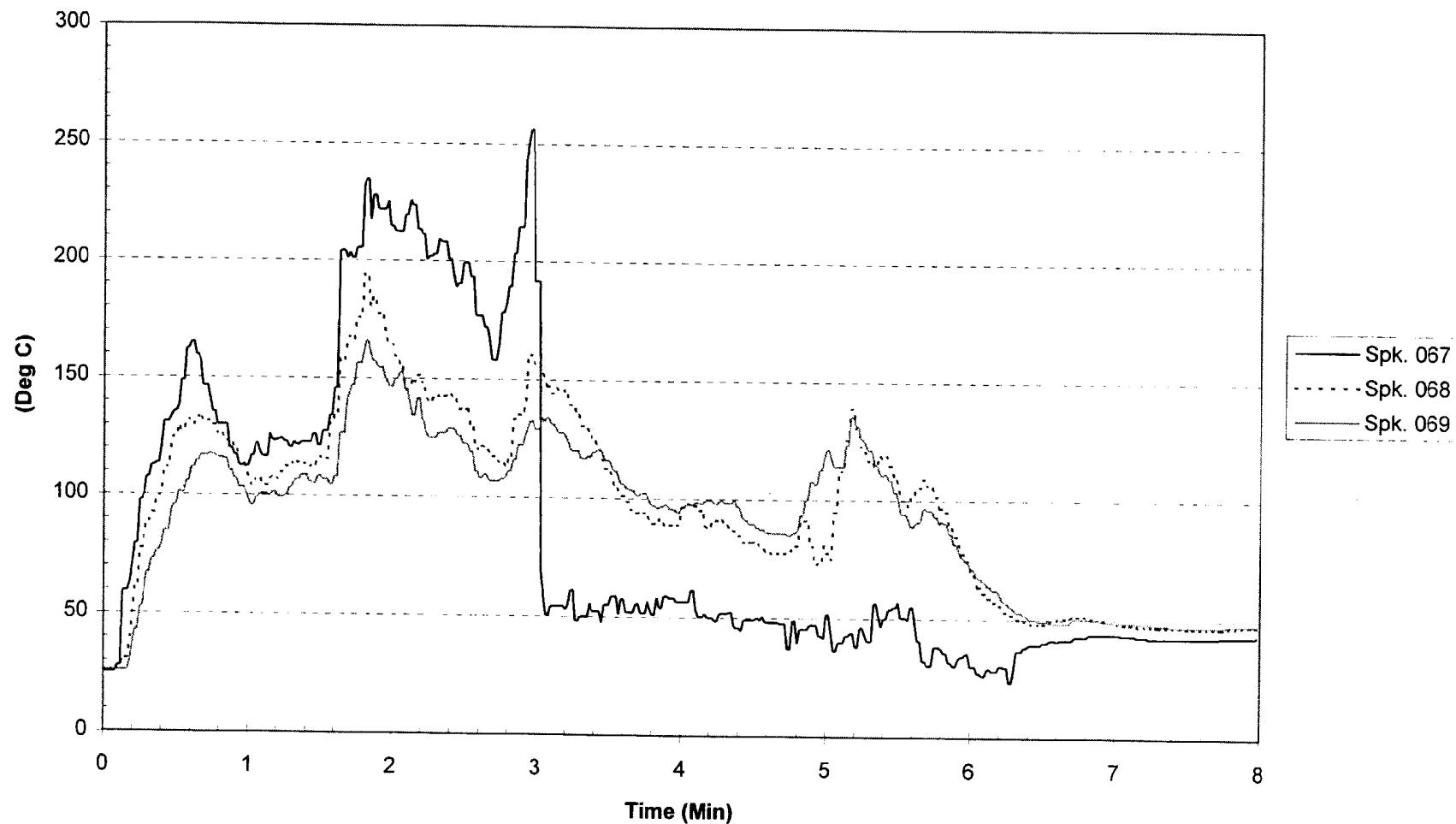
IRI
SP63 - SP65
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

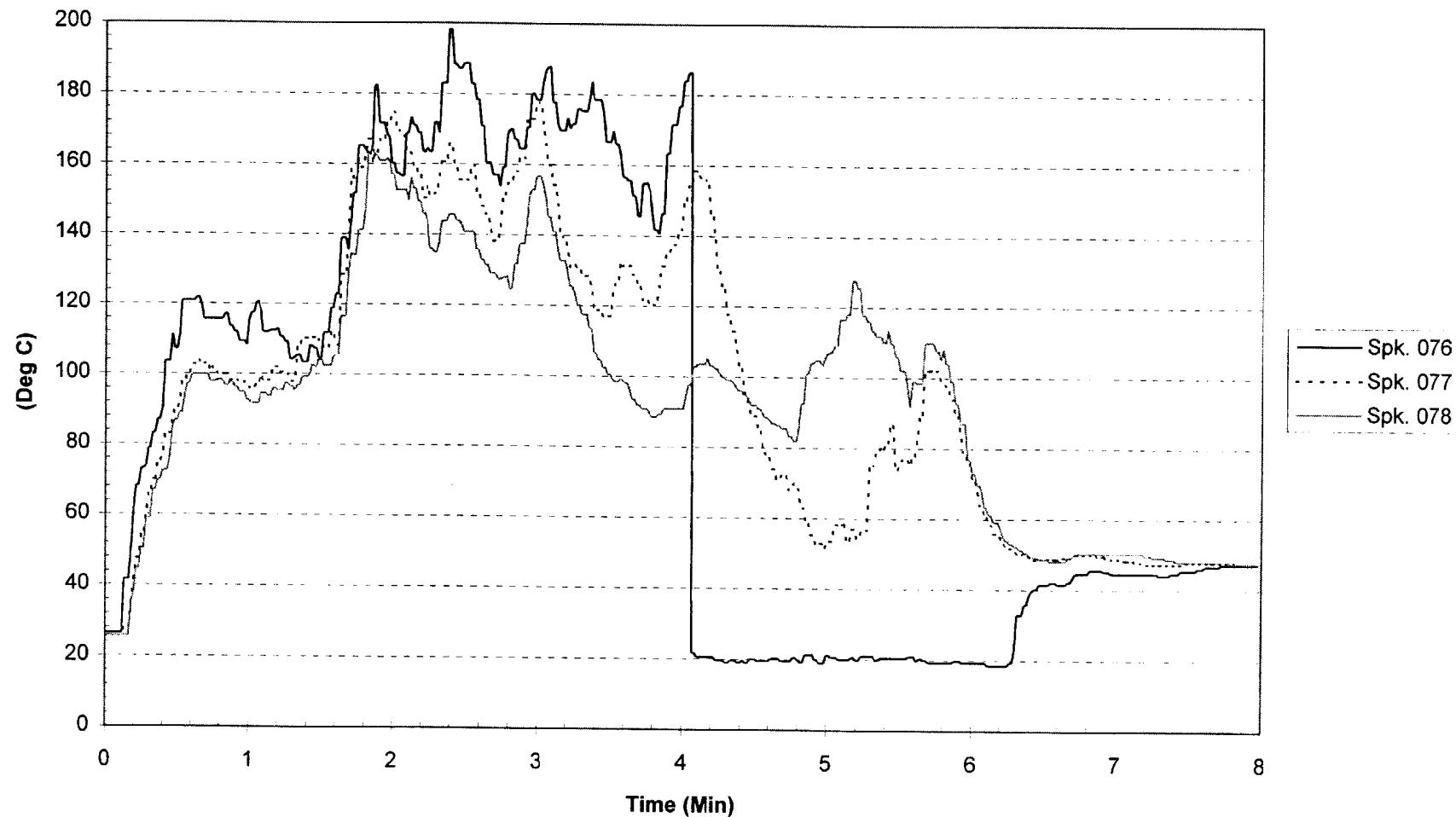
IRI
SP73 - SP75
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

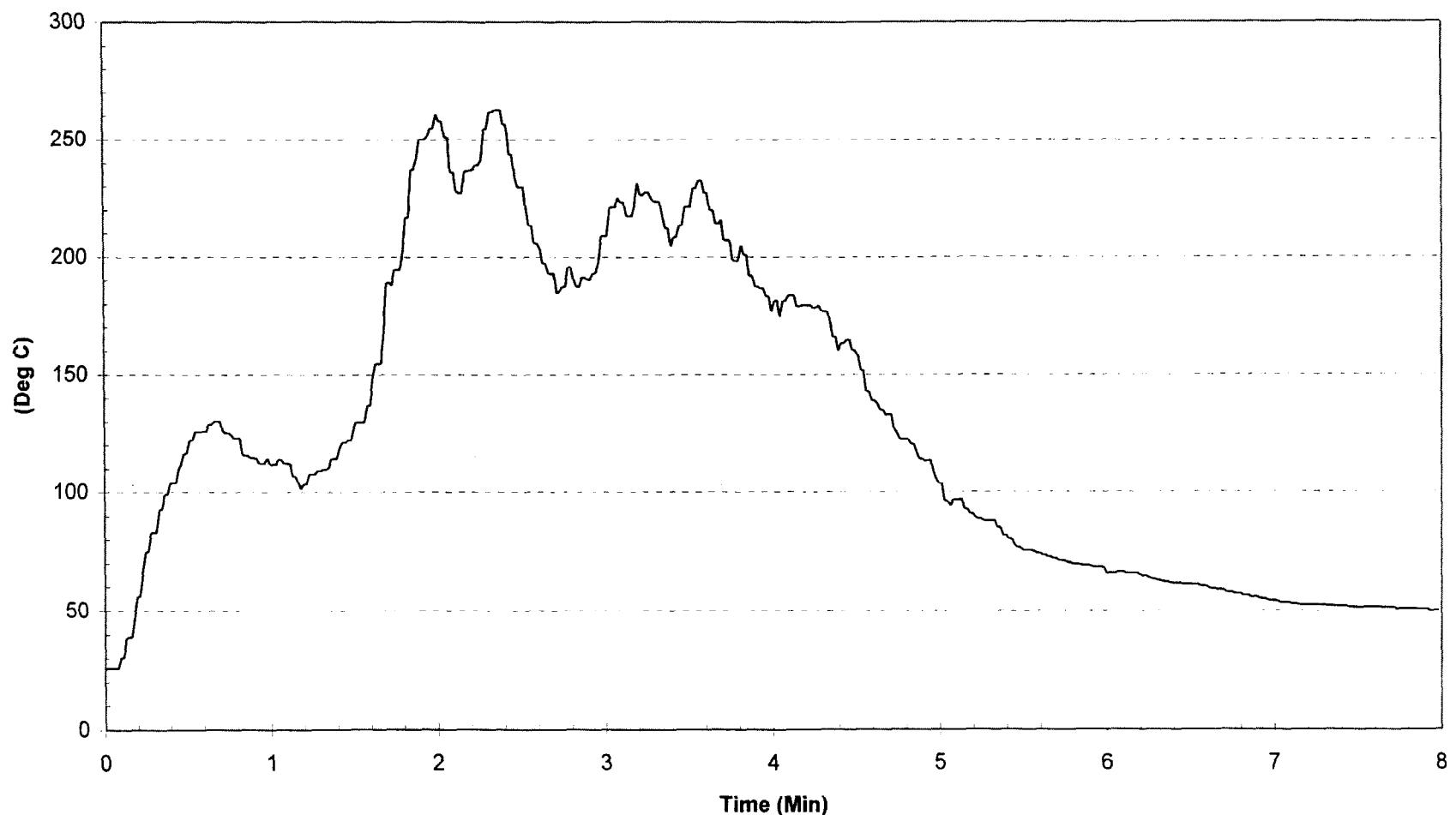
IRI
SP76 - SP78
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

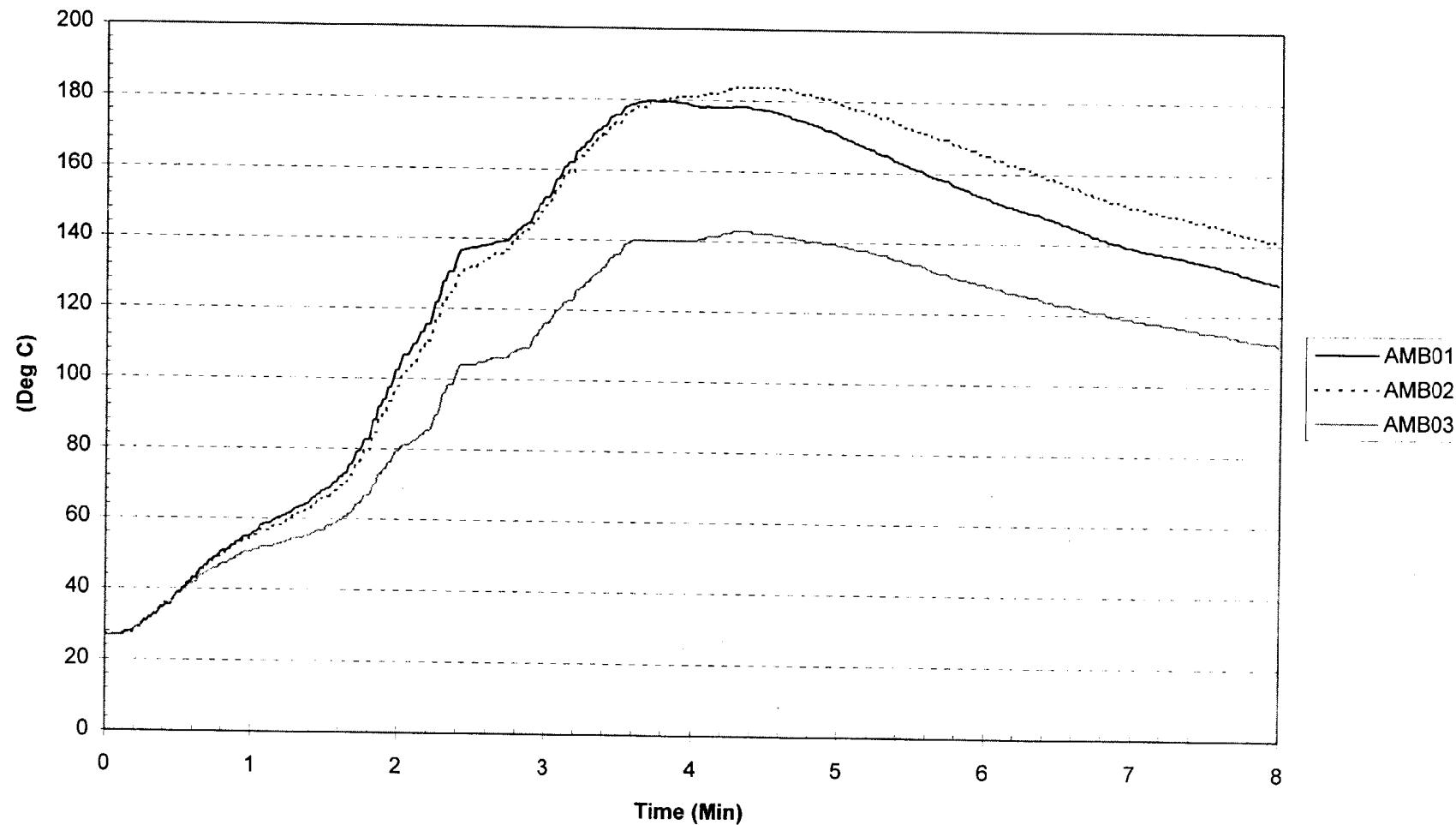
IRI
AIR ABOVE IGNITION
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1

IRI
STEEL ABOVE IGNITION
15 GPM RUNNING HEPTANE FUEL FIRE



NC1838/97NK34585
Test Date : 10/9/97

10099703.BD1